JUL 20 1925

The Journal of HEREDITY

A monthly publication devoted to Plant Breeding Animal Breeding and Eugenics

TWO TYPES OF STRAWBERRY FLOWERS

(See Page 193)

Sex Types in the Strawberry
George Darrow

Introduction of the Potato
W. E. Safford

Mendelian History of Shorthorn Cattle
H. C. McPhee and Sewall Wright

Electrogenetics
A Review

Gifted Children
A Review

JUNE, 1925

VOL. 16 No. 6

The American Genetic Association

President, David Fairchild — Vice-President, W. E. Castle — Secretary, Sewall Wright

Treasurer, Boyd Taylor

EDITORIAL BOARD

C. E. LEIGHTY — R. R. GRAVES — L. C. DUNN

WILSON POPENOE — GEORGE M. DARROW — PAUL POPENOE

Members of the Council are ex-officio members of the Editorial Board

Managing Editor: ROBERT C. COOK

COUNCIL

W. E. CASTLE, Professor of Zoology, Harvard University, and Research Associate of the Carnegie Institution of Washington.
LEON J. COLE, Professor of Genetics, University of Wisconsin.
G. N. COLLINS, Botanist, U. S. Department of Agriculture, Washington, D. C.
O. F. COOK, Bionomist in Charge of Breeding Investigations, U. S. Department of Agriculture.
DAVID FAIRCHILD, Agricultural Explorer in Charge, U. S. Department of Agriculture.
GILBERT GROSVENOR, President National Geographic Society, Washington, D. C.
T. H. KEARNEY, Physiologist in Charge of Drought-Resistant Plant Breeding Investigations, U. S. Department of Agriculture.
VERNON KELLOG, Chairman, Division of Educational Relations, National Research Council, Washington, D. C.
J. H. KEMPTON, Bureau of Plant Industry, U. S. Department of Agriculture.
E. W. SHEETS, Chief of Animal Husbandry Division, U. S. Department of Agriculture.
FREDERICK ADAMS WOODS, Lecturer on Biology, Massachusetts Institute of Technology.
SEWALL WRIGHT, Senior Husbandman in Animal Genetics, U. S. Department of Agriculture.

ADVISORY COMMITTEE

W. S. ANDERSON, Genetics Department, University of Kentucky, Lexington, Kentucky.
E. B. BABCOCK, Genetics Department, University of California, Berkeley, California.
E. A. BESSEY, Professor of Botany, Michigan Agricultural College, East Lansing, Michigan.
A. F. BLAKESLEE, Plant Genetist, Carnegie Institution, Cold Spring Harbor, New York.
J. K. BREITENBECHER, Professor of Zoology, University of Oklahoma, Norman, Oklahoma.
W. E. BRYAN, Professor of Plant Breeding, University of Arizona, Tucson, Arizona.
C. B. DAVENPORT, Director, Department of Genetics, Carnegie Institution of Washington, Cold Spring Harbor, L. I., New York.
J. A. DETLEFSEN, Professor of Genetics, Wistar Institute, Philadelphia, Pennsylvania.
RUSSELL W. DUCK, Professor of Animal Husbandry, Syracuse University, Syracuse, New York.
E. M. EAST, Professor of Plant Genetics, Bussey Inst. of Applied Biology, Boston, Mass.
R. A. EMERSON, Professor of Plant Breeding, Cornell University, Ithaca, New York.
C. P. GILLETTE, President, The Genetic Foundation, Fort Collins, Colorado.
C. M. GOETHE, Sacramento, California.
FREDERICK O. GROVER, Professor of Botany, Oberlin College, Oberlin, Ohio.
ROBERT T. HANCE, Rockefeller Foundation for Medical Research, New York City.
HARRISON R. HUNT, Professor of Biology, Michigan Agricultural College, East Lansing, Mich.
R. E. HUNT, Professor of Animal Husbandry, Virginia Polytechnic Institute, Blacksburg, Virginia.
H. S. JENNINGS, Professor of Zoology, Johns Hopkins University, Baltimore, Maryland.
D. F. JONES, Plant Breeder, Connecticut Agricultural Experiment Station, New Haven, Conn.
F. B. LINFIELD, Director, Montana Experiment Station, Bozeman, Montana.
WM. A. LIPPINCOTT, Professor of Poultry Husbandry, University of California, Davis, Cal.
C. C. LITTLE, President, University of Maine, Orono, Maine.
JAY L. LUSH, Animal Husbandman, Texas Agricultural Experiment Station, College Station, Texas.
H. H. NEWMAN, Professor of Zoology, University of Chicago, Chicago, Ill.
T. S. PALMER, Expert in Game Conservation, U. S. Dept. of Agriculture, Washington, D. C.
JOHN H. PARKER, Professor of Astronomy, Kansas State College, Manhattan, Kansas.
MRS. CHARLES C. RUMSEY, Wheatley Hills, Westbury, Long Island.
THOMAS W. SALMON, Professor of Psychiatry, Columbia University, New York City.
JOHN M. SCOTT, Vice Director, Florida Agricultural Experiment Station, Gainesville, Florida.
JOHN W. SCOTT, Professor of Zoology, University of Wyoming, Laramie, Wyoming.
A. D. SHAMEL, Pomologist, U. S. Department of Agriculture, Riverside, California.
GEORGE H. SHULL, Professor of Biology, Princeton University, Princeton, New Jersey.
W. W. SMITH, Professor of Animal Husbandry, Purdue University, Lafayette, Indiana.
CHARLES R. STOCKARD, Professor of Anatomy, Cornell University, New York City.
A. B. STOUT, Director of Laboratories, New York Botanical Gardens, New York City.
W. T. SWINGLE, Plant Physiologist in Charge of Breeding Investigations, U. S. Department of Agriculture, Washington, D. C.
LOU D. SWEET, Seedsman, Denver, Colorado.
E. L THORNDYKE, Professor of Educational Psychology, Columbia University, New York City.
L. H. TOMHAVE, Head of Department of Animal Husbandry, Pennsylvania State College, State College, Pennsylvania.
H. E. WALTER, Professor of Biology, Brown University, Providence, Rhode Island.
H. J. WEBBER, Director, Citrus Experiment Station, Riverside, California.
E. N. WENTWORTH, Armour's Bureau of Agr'l Research and Economics, Chicago, Illinois.
P. W. WHITING, Department of Biology, University of Maine, Orono, Maine.
JOHN A. WIDTSOE, 47 E. South Temple St., Salt Lake City, Utah.

The

Journal of Heredity

VOL. XVI, No. 6 June, 1925

CONTENTS

IMPORTANCE OF SEX IN THE STRAWBERRY.....GEO. M. DARROW 193

THE CHILDLESS FAMILY (A Review)..... 204

MENDELIAN ANALYSIS OF THE PURE BREEDS OF LIVE-STOCK.....H. C. MCPHEE AND SEWALL WRIGHT 205

ELECTROGENETICS (A Review)..... 215

BACK NUMBERS WANTED..... 216

THE POTATO OF ROMANCE AND OF REALITY....W. E. SAFFORD 217

GIFTED CHILDREN (A Review)..... 230

A NEW PUBLICATION..... 230

The JOURNAL OF HEREDITY is published monthly by the

AMERICAN GENETIC ASSOCIATION

At 1918-32 Harford Avenue, Baltimore, Md., and

Victor Building, Washington, D. C.

Address communications regarding editorial matters and the business management of the Association to Room 306, Victor Building, Washington, D. C.

Entered as second class matter February 24, 1923, at the post office at Baltimore, Maryland. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized December 20, 1918. **Contents copyrighted 1925 by the American Genetic Association. Reproduction of articles or parts of articles permitted only upon request, for a proper purpose, and provided due credit is given to the author and to the JOURNAL OF HEREDITY, Washington, D. C.**

Date of Issue of This Number, July 11, 1925

$3.50 a Year; 35c the Copy

A PERFECT-FLOWERED STRAWBERRY BLOSSOM

Frontispiece

Both pistils and stamens are contained in the same flower. Varieties bearing such flowers are called hermaphrodite, and since they are self-fertile, large plantings of a single perfect-flowered variety will produce abundant crops of berries.

Hermaphrodite varieties are by no means a uniform group. Some that appear to have perfect stamens produce abortive pollen, and others have sterile pistils. These variations are of much practical importance to the grower because failure to set fruit may cause serious loss.

THE IMPORTANCE OF SEX IN THE STRAWBERRY

George M. Darrow

BASED on their sex expression, two forms of strawberry flowers are commonly recognized, pistillate and hermaphrodite. Pistillate flowers contain pistils, but lack stamens. Hermaphrodite flowers contain both pistils and stamens.

All varieties whose flowers lack stamens are called pistillate; all others are called hermaphrodite or perfect-flowered sorts. In the field, growers do not commonly consider it necessary to mix hermaphrodite varieties to insure cross-pollination, but set large acreages to single sorts. If pistillate varieties are grown they usually alternate two rows of a pistillate sort with one of the hermaphrodite type to furnish pollen.

The classification of sex types in the strawberry and the disposal of problems arising from differences in flower types is not as simple as the above statements seem to indicate. Sex expression in the strawberry is and always has been one of the most important problems in raising strawberries, for the form of sex shown by any variety in a field determines to a large extent the possible crop.

Pistillate varieties as commonly thought of do actually constitute at present a fairly definite group. Their flowers are practically always lacking in pollen and nearly always set fruit when pollinated.

Hermaphrodite varieties are most distinctly not a uniform group. Though all varieties which appear to have morphologically perfect stamens and pistils are placed in this class, every breeder and every close observer of wild strawberries knows that there is the greatest possible variation in this group. Some often bear a large proportion of pistillate flowers; others bear flowers in which the pollen is nearly all abortive and are thus practically pistillate sorts. Most common and of much the greatest importance are hermaphrodite varieties in which the pistils of a greater or less proportion of the flowers are sterile. All or nearly all cultivated hermaphrodite varieties show this sterility. Under some conditions not one in fifty of the flowers of some varieties set. This is not due to frost, nor to cold, nor to rain, nor even to lack of pollen, but to sterility of the pistils. Proof of this statement is easily secured by examining the setting of the flowers of pistillate varieties and comparing them with adjacent hermaphrodite varieties.

Seventy-five to ninety-five years ago it was quite well known that there were differences in the sex of the so-called hermaphrodite varieties — far better known than it is today. This was due to the studies of Nicholas Longworth and his associates.

Studies of Longworth and Associates

The attention of Longworth was first directed to the sex differences in strawberries by the success of a market gardener, Mr. Arbigust of Philadelphia, who later moved to Cincinnati. This gardener had discovered that some varieties were pistillate, that others had flowers containing both pistils and stamens, and that by planting pistillate varieties with some plants of the perfect-flowered sorts nearby the largest crops were produced. Longworth recognized the importance of this, and by his addresses and writings between 1835 and 1860 made it common knowledge throughout America.

Longworth was aided in his studies and in his publicity work by the Cincinnati Horticultural Society. Various

committees of this society made reports on their studies of the sex of the strawberry, during which millions of flowers were examined. Since the time these reports were made many of their findings have been forgotten. Yet some of their findings are of greatest importance to breeders and physiologists today.

Among their conclusions are the following:

1. That the different varieties have characteristic inflorescences.

2. That the differences in their inflorescence consist in the greater or less development of the stamens and pistils.

3. That while in some varieties the flowers are apparently perfect, the pistils are really to a greater or less extent defective.

4. That in pistillate varieties stamens are in most instances wholly abortive and such sorts will not bear a perfect fruit if kept apart from staminate varieties.

5. That no varieties with flowers containing stamens could be depended upon as heavy bearers, "though from some unknown causes, the pistils may be so well developed as to be followed by a good crop, some years and in some locations."

6. That there is no known perfect-flowered variety in which the blossoms will all be followed by perfect fruit every year. [One report, however, mentions three varieties that always have both stamens and pistils fully developed in all flowers. These are the La Grange (a variety of *F. elatior*), the White Pine and the Monthly Alpine (*F. vesca semperflorens*)[1]. La Grange was at another time reported as having from 7 to 90 per cent of its flowers sterile.]

7. That the only certain method of producing large crops was to set pistillate varieties with only as many perfect-flowered sorts as might be necessary for pollinating.

At one time four classes were reported: Pistillate, staminate, hermaphrodite and a rare fourth class which bore both pistillate and hermaphrodite flowers on the same plant.

One report stated that not more than thirty per cent and on the average not more than one in twelve of the flowers of hermaphrodite varieties ever set. They even left a record of the percentage of flowers that set in various hermaphrodite sorts. The following is a record of some of the varieties they examined:

Keens Seedling—about 15 per cent of the flowers develop perfect fruit.

British Queen—no flowers develop perfect fruit.

Grove End Scarlet—10 per cent develop perfect fruit.

Ross Phoenix—10 per cent develop perfect fruit.

Swainstone—15 per cent develop perfect fruit.

Eberleins Seedling—43 per cent develop perfect fruit.

Buists Prize—4 per cent develop perfect fruit.

Baynes Seedling—2 per cent develop perfect fruit.

Duke of Kent—23 per cent develop perfect fruit.

La Grange (var. *F. elatoir*)—10 to 95 per cent with an average of about 52 per cent develop perfect fruit.

The average setting of the flowers of all the above varieties is seventeen per cent. Longworth reported that in growing seedlings fully one-half of them were hermaphrodite and that not one in fifty of these hermaphrodites bore even a single berry. He further stated that all the white varieties and the Alpines have good stamens and pistils in all flowers, but that of only one other variety was this true. In all other hermaphrodites some at least of the flowers were sterile.

In the eighty years since these reports were made a great change has taken place in the sex type of commercial varieties. At the time of Longworth's studies pistillate varieties were recommended as being much more productive than hermaphrodite sorts. The best varieties of the latter type, according to the only record available, set only seventeen per cent of their flowers. Today, however, pistillate varieties constitute but a small percentage of the total acreage of strawberries. Some at least of the hermaphrodite varieties are as productive as pistillate sorts and in general they set a much greater proportion of their crop than

[1]Report on the Cultivation of the Strawberry. *Report of Transactions of the Cincinnati Horticultural Society*. 1846. Pp. 59-61.

PISTILLATE STRAWBERRY BLOSSOM

Figure 1

This type of flower has no functional stamens, so that hermaphrodite varieties must be planted with pistillate-flowered ones to furnish pollen. Formerly the pistillate varieties were much more productive than the hermaphrodite, but at the present time there does not appear to be much difference between the two types.

did the hermaphrodite varieties of eighty years ago.

Studies of Valleau

Recently Valleau[2] made a detailed study of sterility in the strawberry. On the basis of their sex expression, he grouped varieties into three classes, pistillate, staminate and perfect-flowered. He found that the flowers of all *pistillate* varieties bore "staminodia" (abortive stamens) showing varying degrees of development but which never produced pollen. *Staminate* varieties had pistils which appeared normal but which did not set fruit. Staminate sorts were found in which the first flowers to open were pistillate and bore only staminodia

[2]VALLEAU, W. D. 1918. Sterility in the Strawberry. *Jour. Agr. Res.* Vol 12, No. 10, pp. 613-670.

VARIATION IN FLOWER DEVELOPMENT

Figure 2

Progressive strawberry plant with flowers having: (1) normal petals but abortive stamens; (2) staminodia only; and (3) partially developed petals and staminodia. Apparently under unfavorable conditions the anthers do not develop properly. If the conditions are still more adverse the stamens become staminodia, the petals remain small, and the sepals only partially develop. Photographed in the greenhouse, February 25, 1925.

FLOWERS WITHOUT PETALS OR STAMENS

Figure 3

Progressive everbearing strawberry plant brought into flower in February in the greenhouse. Note the six flowers with undeveloped petals and stamens. It is probable that failure to produce normal flowers during the short days of winter limits the number of varieties that can be grown in Florida and other southern regions.

in place of the normal stamens. Cases were even found where only a few of the later flowers produced stamens, all the rest being pistillate. The pistils of such flowers were fertile and produced fruit. Sometimes one or more of the later flowers of staminate varieties were pistillate while the first was staminate. Cases in which one part of a flower was staminate and the other part pistillate were found. In addition a full series of types between the two forms was reported and illustrated. Valleau further stated that all degrees of stamen development might be found on a single cultivated perfect-flowered variety. Varieties such as Lovett, Glen Mary and an unnamed seedling were listed which produced some pistillate flowers early in the season but which later produced all hermaphrodite flowers with good stamens.

Valleau examined the pollen of about 120 varieties of strawberries and found it nearly all perfect in some sorts and nearly all defective in others. For example, in the Glen Mary 46.7 to 100 per cent of the pollen was imperfect while in the Aroma only 1.5 to 22.4 per cent of abortive pollen was found. On the average, however, a little over one-third of the pollen was abortive. In general, the later flowers on an inflorescence contained more good pollen than did the earlier flowers.

Though Valleau reports such widespread pollen abortion in the strawberry, under field conditions growers have little trouble from lack of good pollen. It is probable that where the flowers of a variety contain even as low as five per cent of good pollen a full set of fruit will result. Glen Mary and Progressive are probably the two most widely planted hermaphrodite sorts which generally need another variety set with them.

Valleau also observed another form of sex expression in hermaphrodite varieties—pistil sterility. He does not appear to have realized the economic importance of this condition as fully as did Longworth, partly perhaps because of an actual change in the amount of pistil sterility in the seventy-five or more years intervening. Valleau pointed out that pistil sterility occurs in the wild species *Fragaria virginiana* and *F. chiloensis* from which our cultivated sorts come and also that *F. elatior* of Europe, *F. cuneifolia* from Vancouver Island and Washington State and *F. platypetala* all show more or less pistil sterility. Where pistil sterility occurs he showed that the first flowers to open tend to set while a very great progressive increase in sterility from the first flowers to the last occurs.

In fifteen hermaphrodite varieties under field conditions he found 10.6 per cent of the primary flowers in the clusters failing to set or setting imperfectly, 20.9 per cent in the secondary, 36.7 per cent in the tertiary and 60.6 per cent in the quaternary, or an average of 33 per cent failing to set or setting imperfectly and 67 per cent setting fruit. In a test using 86 hermaphrodite varieties and 39 unnamed seedlings where the flower clusters were bagged, the percentage of setting was much lower. Of primary flowers 73.2 per cent failed to set or formed nubbins, as did 75.1 per cent of secondary flowers, 78.5 per cent of tertiary flowers and 88.2 per cent of quaternary flowers.

Valleau cites instances of changes in the sex type of varieties. He states that it is a matter of common observation that a bed of berries, if allowed to fruit more than one year, will produce an increasing number of small berries and nubbins. A variety, Glenville, only occasionally set fruit in the greenhouse in winter, while the same plants the following summer, when potted, produced over fifty per cent of flowers setting fruit. At the same time in the field the Glenville produced less than two per cent of flowers which set. He notes that the tendency toward the production of staminodia is much greater in early spring than later on in hermaphrodite varieties.

Figure 4

Fruit cluster of the Klondike strawberry, only one flower of which did not set. Great variation in the setting of fruit is found in the perfect-flowered varieties, due chiefly to sterile pistils.

VARIATION IN SETTING OF FRUIT

Figure 5

A typical fruit cluster of the White Pineapple variety. Only the primary and two secondary flowers have set fruit. The other nine flowers were sterile. Because of such sterility growers often secure less than half the crop they should.

ABORTIVE AND NORMAL STAMENS

Figure 6

At the left, three Progressive strawberry blossoms with abortive stamens; at the right a blossom of the Dunlap variety with good stamens.

Observation on Flower Sterility in Maryland

Some records secured in 1924 furnish additional data on the extent and importance of sex expression in different varieties. These records were taken at three places in Maryland—at Salisbury, on a coarse sandy soil; at Glenn Dale, on a fine but variable sandy loam, and at College Park, on a clay loam. Tables I., II. and III. present the data.

The most striking thing shown by these data is the great difference between the percentage of failure to set of the hermaphrodite and the pistillate varieties at each place. At Salisbury the average failure to set of the two types was 34 per cent and 12 per cent, respectively; at Glenn Dale, 28 per cent and 6 per cent, and at College Park, 36 per cent and 18 per cent. Additional records of several pistillate seedlings in 1924 at Glenn Dale show a much lower percentage of flowers failing to set on pistillate varieties. These seedlings showed, respectively, 0, 0, 0, 0, 2, 2, 4, 4, 5 and 5 per cent of flowers failing to set. Observations in former years have indicated that all flowers of many pistillate varieties set under favorable conditions. Fungi, drought, mechanical injuries and other causes commonly prevent the setting of some flowers. Though such causes may explain the failure to set, shown in the tables, it seems probable that pistillate varieties do occur which show some sterility of the later flowers under certain conditions, but more records are needed on this point.

A second striking fact shown by these data is the great variation in the sterility of hermaphrodite varieties. At Salisbury the percentage of failure to set varied from 89 per cent in the Big Wonder to 2 per cent in Lupton. At Glenn Dale, Judith showed 45 per cent not setting; Joe and Klondike each showed 17 per cent. At College Park Burrill showed 75 per cent not setting and Klondike only 12 per cent. Observations in different parts of the United States indicate that corresponding degrees of failure to set exist in most, if not all, regions. The decrease in size of fruit from the beginning to the end of the season varies with the variety, being much greater with some varieties than with others. Because the first berries on a cluster to ripen are the largest and the last ones to ripen are the smallest, the actual loss in yield

per feet-flowered varieties, due chiefly to sterile pistils.

ALL FRUITS SET

Figure 7

Fruit clusters of *Fragaria vesca*, a European wild strawberry, showing that every flower has set fruit. Under all conditions observed, the flowers of this species have invariably just as fertile. Moreover, this is true of all species belonging to the vesca group which have been grown here at the U. S. Horticultural Field Station at Bell, Md.

and in value of the crop is less than the percentage failing to set would indicate. For this reason, where not more than ten per cent of the later flowers are sterile the economic loss is probably small. That part of the potential crop that does set and mature is likely to be of better grade than if the later flowers which would naturally produce small berries were fertile. In those varieties where the size of the later berries does not decrease materially, the economic loss, when even ten per cent of the flowers are sterile, is considerable.

The average failure to set of hermaphrodite varieties at the three places in Maryland in 1924 agrees quite closely with that reported by Valleau. Strawberries at these points show 28, 34 and 36 per cent of flowers failing to set, while Valleau found about 33 per cent in Minnesota. Individual varieties show considerable variation at different places. Valleau reported 41 per cent failing to set in the Parsons. At Salisbury in 1924 it showed 56 per cent and at Glenn Dale 44 per cent sterility. Dunlap showed 56 per cent not setting in Minnesota and 32 per cent at Glenn Dale, Maryland. Joe showed 23 per cent at Salisbury, 17 per cent at Glenn Dale and 28 per cent at College Park, while Klondike showed 14, 17 and 12 per cent, respectively. Small variations in failure to set like those in the Klondike at the different places might be expected, but a difference such as that shown by the Dunlap, with 56 per cent and 32 per cent, indicates that conditions have affected the fertility of the flowers.

Pistillate Flowers on Perfect-flowered Varieties

In a report of a committee of the Cincinnati Horticultural Society referred to above a rare fourth class was reported consisting of hermaphrodite varieties that produced some pistillate flowers. Valleau mentioned this, but does not seem to appreciate the extent of its occurrence. It is more common and has much more influence on the crop than does the development of a very low per cent of good pollen. The first flowers of Dunlap often lack well-developed stamens. During cool weather of early spring this condition seems the most common. As a result the earlier flowers may not be pollinated, and as the first flowers bear the largest fruit, the economic loss may be considerable. Under greenhouse conditions during the short days of winter many varieties develop neither stamens nor petals. It is probable that the lack of stamens under the short days of winter determines to a considerable extent the varieties which can be grown in Florida and other southern sections.

Some records of the flower type of Howard 17, taken in the greenhouse April 7, 1925, about a week after the first flowers appeared, illustrate the extent of the lack of stamens. On 137 plants there were 702 flowers, of which 669 were pistillate and 33, or less than five per cent, were hermaphrodite. A distinct flower type was also noted on these plants—a flower where both stamens and petals were undeveloped, and of the 669 pistillate flowers 144 had no well-developed petals. Where they could be seen the petals were green and rarely as long as the sepals.

A few varieties were examined in the field, May 3, 1924, at Glenn Dale, Maryland, when the first flowers were appearing. Of these the Maryland variety had 6 normal flowers and 32 with abortive stamens, Progressive had 4 normal and 13 abortive, Campbell had 6 normal and 25 abortive and Missionary had 4 normal and 9 abortive.

More extensive records were taken at Salisbury, Maryland, on May 10, 1924, which are given in Table IV. In it are listed 15 varieties having some flowers with abortive stamens and 21 varieties in which all flowers had good stamens.

The following varieties showed no

flowers which did not contain some well-developed stamens:

1. Abington
2. Big Wonder
3. Belt
4. Brandywine
5. Bun (*Bun Special*)
6. Burrill
7. Corneille
8. Campbells
9. Dunlap
10. Early Jersey
11. Ozark
12. Eaton
13. Parsons (*Gibson*)
14. Joe
15. Klondike
16. King Wealthy
17. Lea
18. Marshall
19. Missionary
20. Michels Early
21. Nick Ohmer

Discussion

The studies of Longworth and Valleau and the observations in Maryland recorded above give some idea of sex types in the strawberry. Cultivated varieties may still be grouped into two primary classes, pistillate and hermaphrodite or perfect-flowered forms. Pistillate varieties are apparently distinct from the perfect ones, though it has been reported that certain pistillate varieties become hermaphrodite in England.

Hermaphrodite varieties show a great range of flower types from those bearing pistillate primary flowers and which may even bear many pistillate secondary and tertiary flowers to those whose flowers all have good stamens. Moreover, this latter group grades from hermaphrodite varieties whose flowers all set to those where none set. In a single cross between a pistillate and a hermaphrodite variety a complete series of intergrades or intersexes from nearly perfect-flowered to staminate seedlings may be secured.

Actual records indicate that a change in the setting of hermaphrodite varieties from the time of Longworth to Valleau from seventeen per cent to sixty-six per cent of the flowers setting perfect fruit has occurred. Instead of almost exclusively pistillate varieties, hermaphrodite sorts are now grown almost entirely. Unconscious selection of the most productive hermaphrodite varieties during the seventy-five years has evidently brought about this change in the fertility of hermaphrodite varieties.

While Longworth appreciated the importance of sex types and recognized the principal forms, Valleau studied the exact manner of sex expression in each type and has made it possible for growers and breeders to judge varieties by a new and much more exact measure that is, their sex type and the sterility of the flowers according to their position on an inflorescence.

The problems relating to sex in the strawberry are genetical and physiological. By breeding and selection a great increase in the setting of flowers has been secured. A further increase in their fertility is most important. Under some conditions a much greater percentage of the flowers set than under other conditions and an understanding of the causes of such changes is also important.

TABLE I. Number of flowers per inflorescence and of flowers failing to set of strawberry varieties at Salisbury, Maryland, 1924. (Except as noted 30 clusters were used in getting averages.)

Variety	*Avg. No. Flowers to stalk*	*Per Cent of Flowers Failing to Set*	*Remarks*
1. Joe	10.35	23	31 clusters averaged. Fine foliage.
2. Marshall	9.57	74	Foliage small, leaf spot bad.
3. Brandywine	9.44	22	Fair to good foliage, some leaf spot.
4. Bun (*Bun Special*)	8.73	62	Little leaf spot.
5. Excelsior	8.70	44	Good foliage.
6. Big Wonder	8.47	89	Much leaf spot.
7. Parsons	8.20	56	Poor foliage, some leaf spot.
8. Gold Mine	7.93	16	Fine foliage.
9. Belt (*Wm. Belt*)	7.77	25	Much leaf spot.
10. Fremont Williams	7.73	38	Some leaf spot.
11. Marvel	7.67	19	Good foliage, some leaf spot.
12. Progressive	7.30	14	Fine foliage.
13. Chesapeake	6.90	16	Fine foliage, some leaf spot.
14. Delicious	6.87	34	Leaf scorch—not much spot.
15. Lea	6.83	31	Sparse, small foliage, some leaf spot.
16. Michels Early	6.77	49	Leaf spot bad.
17. Ozark (*Early Ozark*)	6.77	11	Some leaf spot, much calyx injury.
18. Judith	6.53	33	Leaf spot bad.
19. McAlpin	6.16	59	Leaf spot very bad.
20. Easton	5.67	29	Small foliage, some leaf spot.
21. Corneille (*Lady Corneille*)	5.53	28	Much leaf spot.
22. Lupton	5.04	2	Healthy foliage.
23. Klondike	4.17	14	20 clusters averaged.
Avg. perfect-flowered	7.35	34	per cent
Imperfect Flowered Varieties			
24. Big Late	10.60	8	Good foliage, much leaf spot.
25. Warfield	8.82	27	Avg. 28 clusters, poor leaf growth.
26. Paul Jones	6.44	11	Avg. 27 clusters—slight leaf spot.
27. Fendall	6.13	3	Little leaf spot.
Avg. pistillate-flowered	8.09	12	per cent

TABLE II. Number of flowers per inflorescence and percentage of flowers failing to set, of strawberry varieties at the Bell Horticultural Field Station, Glenn Dale, Maryland, 1924.

Variety	*Av. No. Flowers Per Stalk*	*Per Cent Flowers Failing to Set*	*Remarks*
1. Belt	15.9	21	8 clusters
2. *F. virginiana*, #13	13.4	38	26 clusters
3. Joe	13.4	17	10 clusters
4. Parsons (*Gibson*)	13.4	44	20 clusters
5. Marshall	9.6	26	10 clusters
6. Dunlap	7.7	32	14 clusters
7. Klondike	7.0	17	10 clusters
8. Judith	5.2	45	30 clusters
Average perfect-flowered	10.7	28	
Imperfect Flowered Varieties			
9. Sample	11.8	12	10 clusters
10 *F. virginiana*, #9	10.3	3	19 clusters
11. *F. virginiana*, #15	7.1	2	29 clusters
12. Howard 25	6.2	6	10 clusters
Average pistillate flowered	8.9	6	

TABLE III. Number of flowers per inflorescence and percentage of flowers failing to set, of strawberry varieties, College Park, Maryland, 1924.

	Avg. No. Flowers Per Stalk	*Per Cent Failing to Set*
1. Wyona	10.10	43
2. Joe	9.87	28
3. Late Stevens	9.13	48
4. Tennessee	8.77	23
5. Burrill	8.17	75
6. Charles I	7.40	35
7. Klondike	6.47	12
8. Lupton	5.67	25
Average perfect-flowered	8.20	36 per cent
Imperfect Flowered Varieties		
9. Sample	9.87	21
10. Bubach	7.60	14
Avg. pistillate-flowered	8.47	18 per cent

TABLE IV. Number of hermaphrodite flowers and flowers lacking well developed stamens in strawberry varieties at Salisbury, Maryland, May 10, 1924.

	No. of Hermaphrodite Flowers	*No. of Flowers Lacking Well-Developed Stamens*
1. Marvel	3	47
2. Progressive	6	44
3. Shropshire	10	30
4. Delicious	43	57
5. Tennessee	25	25
6. McAlpine	25	25
7. Judith	12	8
8. Late Stevens	3	2
9. Klondike	14	6
10. New York	42	13
11. Gold Mine	30	9
12. Ekey	46	4
13 Howard 17	41	1
14. Lupton	49	1
15. Gandy	50	1

The Childless Family

URSACHEN UND BEHANDLUNG DER UNFRUCHTBARKEIT NACH MODERNEN GESICHTSPUNKTEN, by Prof. DR. E. KEHRER, director of the municipal gynecological clinic, Dresden. Pp. 113, with 4 tables, 13 curves, and 2 illustrations, price $1.00. Dresden and Leipzig, Verlag von Theodor Steinkopff, 1922.

The proportion of childless marriages in civilized countries is now something like ten or fifteen per cent. While some of these are deliberately childless, it is the opinion of many students that the majority of parents would like at least one child, sooner or later, and that therefore the majority of childless marriages of long duration represent actual sterility. The cause and cure of this condition is an important part of practical eugenics.

In this clear and detailed treatise the author lays the greatest emphasis on dyspareunia as a cause of sterility. The book is a valuable contribution to a question that is of both personal and national concern.

P. P.

MENDELIAN ANALYSIS OF THE PURE BREEDS OF LIVESTOCK

III. The Shorthorns

HUGH C. MCPHEE and SEWALL WRIGHT

Bureau of Animal Industry, United States Department of Agriculture

MUCH has been written about the role of inbreeding in the development of the pure breeds of livestock but the illustrations have been confined largely to pedigrees of certain individuals chosen in most cases merely as notorious examples of close inbreeding. Similarly, the importance of "prepotent" sires has been popularly discussed in breed literature but again for the most part without any definite measures of their influence. After reading the glowing accounts of the achievements of early breeders one often has an uneasy feeling that all of this may have had to do merely with a temporary aristocracy of show ring winners and have had little to do with the many thousands of animals which make up the rank and file of the breed, or even to any permanent extent with the more improved section of the breed.

Pearl, Gowen and others[2,3,4] have published studies dealing with the extent to which inbreeding is being practiced at present in the Jersey and Holstein-Friesian breeds of cattle. They find very low figures, especially for the latter breed. These results, as will be seen, agree with those which we have obtained for the Shorthorns. It may be well to point out here that such a result as regards current inbreeding is not incompatible with a high degree of inbreeding relative to the foundation stock. In the present paper we shall be concerned more with questions of breed origin and development than with current practices.

A noteworthy numerical analysis of the question of breed composition is that recently published by D. F. Malin[2], who deals with the Shorthorn, Hereford and Aberdeen-Angus breeds of cattle and the Poland China and Duroc Jersey breeds of swine. His method is the determination of the percentages of the blood of outstanding sires contained in the ancestry of the better stock of today as represented by a carefully selected list of the leading sires of prize winners and by a number of other animals of recognized importance. We shall have frequent occasion to compare his results with those obtained by the methods used here.

The preceding paper of the present series[8] presented the results of a detailed study of the breeding of a particular noted strain of Shorthorn cattle, Bates' Duchess family, in terms intended to be readily interpretable on a Mendelian basis. It should be said, however, that while this family has been of great importance in the development of the breed, it should not be considered as typical.

In order to obtain a proper perspective it is desirable to learn the situation in the breed as a whole. The purpose of the present paper is to give in broad outline the history of the British Shorthorns with respect to the use of inbreeding, the influence of particular sires, and the degree of homegeneity of the breed. The Shorthorn breed is especially adapted to such a study because of the relative completeness of the records of the foundation period. While the first herd book was published in 1822, almost forty years after the Collings began their work, a great many of the pedigrees extend back to animals of the latter period. Since the

above date, the records are practically complete. All but two or three per cent of lines of ancestry of modern animals, chosen at random, can be traced back this far.

Methods

The methods of analysis are essentially those described in the first paper[7] of this series. The coefficient of inbreeding measures the correlation between the uniting germ cells with respect to their genetic constitution, relative, of course, to the diversity of the foundation stock[8]. This coefficient measures also the percentage decrease in heterozygosis relative to that in the foundation stock. The coefficient of relationship is simply the correlation between the genetic constitutions of the individuals concerned. It represents the correlation to be expected in appearance with respect to non-dominant characteristics which are determined entirely by heredity. Since the formulae and method of calculating these coefficients have been previously discussed in detail[9] they need not be repeated here. It may be well to call attention to the fact, however, that they are simple deductions from the Mendelian theory of heredity.

It should be emphasized that the coefficient of inbreeding cannot be expected to yield significant information concerning the approach toward homozygosity of particular factors in individual animals. It should give, however, the average approach toward homozygosity when a large number of factors are considered even as applied to individuals and, of course, with greater reliability as applied in large populations. A similar caution applies to the interpretation of the coefficient of relationship.

In the study of Bates' Duchesses the pedigrees were traced complete to the foundation animals. The coefficients calculated from such pedigrees should measure, therefore, the relative degree of homozygosis of the individuals as well as the actual degrees of resemblance to each other in characteristics involving a sufficiently large number of factors to eliminate the vagaries of random sampling.

The present study is an analysis of a breed rather than of individuals. In such a study it is, of course, impossible to consider all the animals of the breed and the analysis must be confined, therefore, to a random sample. In our study not only have the individuals been chosen at random from the appropriate herd books, which represent the registered breed at particular times, but also a strictly random selection of the ancestral lines of the parents of these animals has been made. The first step in obtaining the random sample has been to ascertain the number of pages in the herd book occupied by registrations in the year in question, and then to divide this range into such regular intervals as would yield the desired number of individuals on taking the first animal at the top of the page. In tabulating the lines of ancestry of the parents of these animals, a random sequence of sires and dams has been obtained by following the sequence of heads (sires) and tails (dams) in coin tossing experiments, a different sequence being used in each case. The coefficients depend in the main upon the percentage of occurrence of connections between the chosen ancestral lines of sire and dam of the individuals.

Whether the result obtained from a certain sized sample represents accurately the condition of the entire breed is purely a question of random sampling. A probable error may be obtained by the usual methods. A detailed discussion of the methods is now in press[9].

The period for which samples have been taken, the size of sample, and the number of ancestral lines tabulated in each are shown in Table I. It will be noted that the samples taken from the year 1810 are larger than those of other periods. This condition has resulted from the selection of all of the registered bulls and cows born in the years 1809, 1810 and 1811. Since the number born in 1810 was too small for

the purpose of this study it was decided to select also all those born in the year preceding and following. Four ancestral lines, two back of the sire and two back of the dam, have been tabulated for each of the groups of bulls, except those of the 1920 period, for which only two lines have been tabulated. In the case of the groups of cows four lines have been tabulated only for those born in the 1810 period, all the others being two line pedigrees. The method of using four line pedigrees was used at first because of the greater amount of information furnished for the same amount of work. A change was made to the two line pedigree on recognition of its more satisfactory character from the standpoint of random sampling. It did not seem necessary to repeat the work done by the four line method since practically it should give as reliable results as the other unless the breed showed much more breaking up into distinct lines than our data indicate.

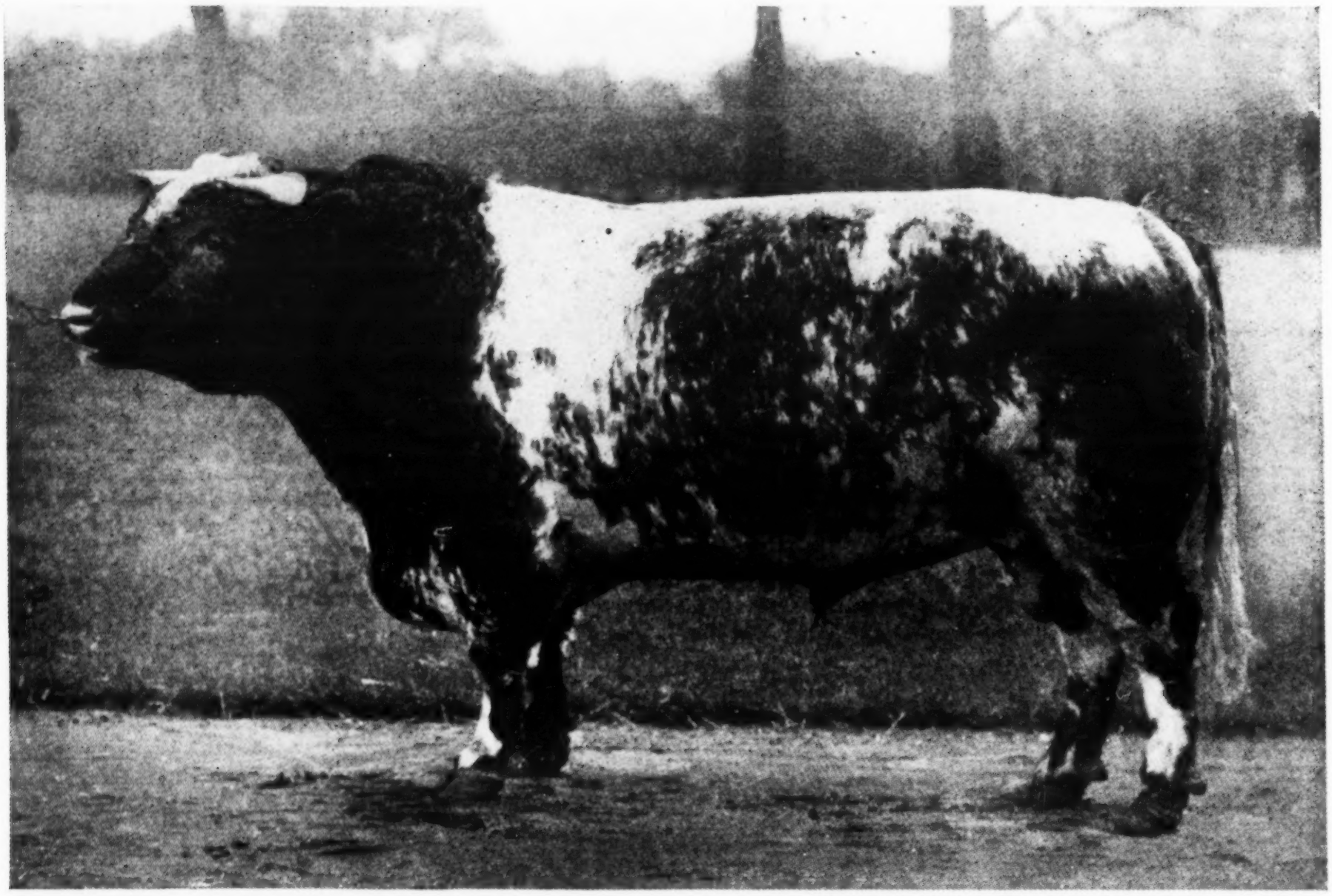
In addition to the study of the entire breed, coefficients of inbreeding and relationship have been calculated for the twenty leading Shorthorn prizewinning sires at the International Livestock Exposition during the years 1918-22. These were taken from Malin's book. Malin has determined the relative importance of each of these sires by assigning different weights to each as sires, grandsires or great grandsires of 1st, 2d and 3d prizewinners. The list of total weights assigned is given in Table II.

The History of the Breed

The Shorthorn breed originated in northeastern England. The original stock was probably a rather heterogenous mixture of native British, Saxon and possibly some Norman cattle. A rather extensive use of imported Dutch bulls upon such native cows took place during the sixteenth and seventeenth centuries and is credited by Wallace[5] with imparting to the Shorthorn breed "its most distinctive characteristics, large size, short horns, broken colour and fine dairy qualities." The genetic homogeneity of this stock relative to the general stock of England at that time cannot be estimated but doubtless it was slight. Outcrosses with other cattle were common during the early period but became rare after the middle of the eighteenth century.

The names and achievements of several prominent breeders of the middle and latter part of the eighteenth century stand out in history as testimony of a period of enthusiastic effort toward the improvement of the Shorthorn breed within itself. The best of the products of the earlier breeders seem to have been brought together in the herds of Charles and Robert Colling about 1780. Probably the greatest individual product of their breeding was the famous bull Favourite (252), dropped in 1793. His ancestry has been given in a previous paper[7]. The Collings bred him to his daughters generation after generation with notable success. Such families as the Duchesses discussed in a previous paper[5] were founded largely on his blood. Through the efforts of Thomas Bates (1775-1849), the Booths, and many others, his blood became diffused to such an extent that he may almost be said to have sired the entire breed.

What may be designated as a second period of breed improvement has been the development of the so-called Scotch type of Shorthorns, based in general on the herd of Amos Cruickshank (1808-1895) at Sittyton, Aberdeen, Scotland, and especially on his noted bull, Champion of England (17526), dropped in 1859. The herd had its origin in animals from many sources selected without regard to blood lines but with particular attention to vigor, early maturity, compactness, short legs and ability to lay on flesh rapidly. This type is somewhat of a contrast to that of some of the earlier herds, such as that of Bates, in which milk production was given considerable attention. The Scotch type predominates in the Shorthorn breed today.



Photograph by Courtesy of Robert Wallace.

THE CRUICKSHANK TYPE OF SHORTHORN

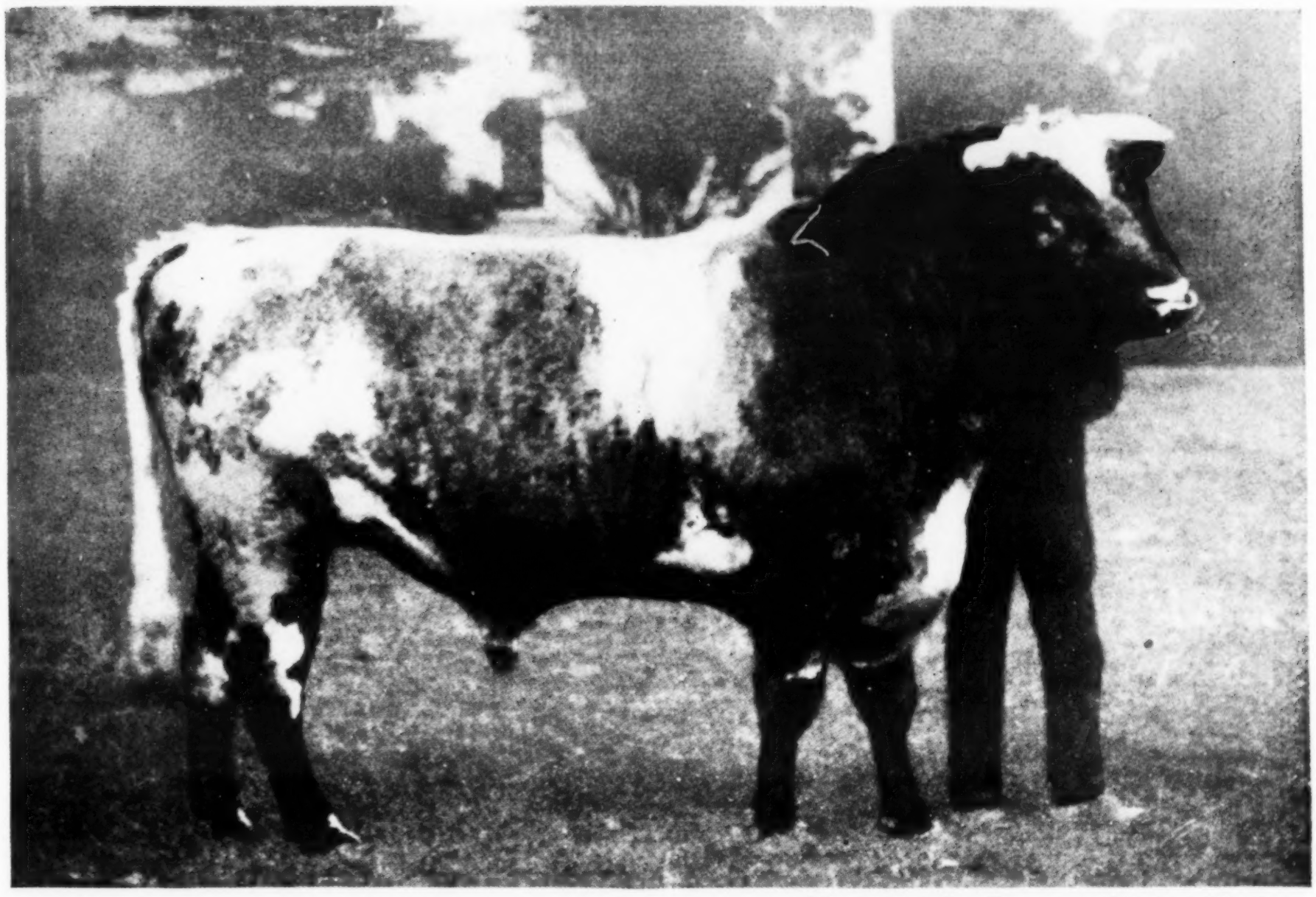
Figure 8

The rugged type and coarse bone of the Cruickshank bred stock is well illustrated by the above photograph of the Shorthorn bull "Field Marshal," (47870). A comparison with the photograph of "Earl of Oxford 3rd" shows the contrast between the type bred by Bates. The Cruickshank type predominates in the breed today.

Average Inbreeding

The problem of the present paper is to obtain numerical measures of the genetic situation in the breed throughout its history. First, consideration will be given to the degree of inbreeding. Figure 10 shows the coefficients of inbreeding of bulls and cows of the British Shorthorns during the period 1810-1920. The previously obtained coefficients of Bates' Duchesses are given for comparison. The figures for the whole breed, as represented in Coates' Herd Book, show a rather abrupt rise in the coefficient from 0 in 1790 to about 17 per cent in 1810. By 1825 it had risen to 20 per cent. It has changed relatively little to the present time, the figure for 1920 being 26 per cent. It is likely, however, that the figure for 1810 is somewhat too high to be representative of the whole breed at that time. Probably only the best bred animals of this period were recorded in the first volume of Coates' Herd Book which was published twelve years later. It should also be mentioned here that the choice of 1790 to represent the period of the foundation stock, relative to which all the coefficients are to be interpreted, is somewhat arbitrary. It was chosen as a date just preceding the birth of Favourite.

The relatively high level of inbreeding which was undoubtedly reached before 1825 and to a large extent before 1810, must be attributed to the direct influence of the Colling bred stock. Bates' Duchesses represent an extreme example of the concentration of this blood but the early herd books show that many other breeders of the time



Photograph by Courtesy of Robert Wallace.

THE BATES TYPE OF SHORTHORN

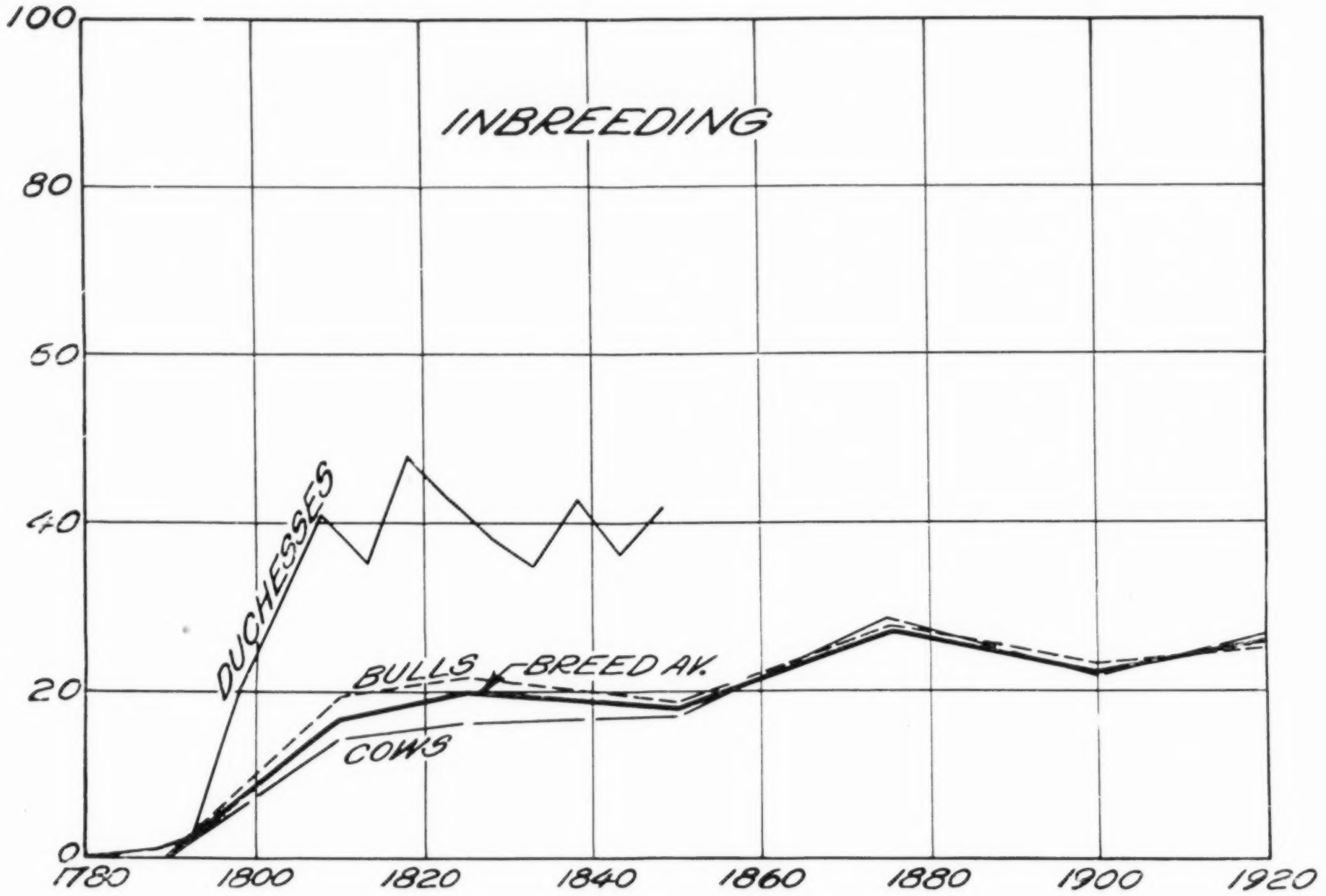
Figure 9

This photograph of "Earl of Oxford 3rd," (51186) illustrates the compact build, smoothness, and the fineness of bone which was characteristic of the latter day Bates type Shorthorns.

were following the same course to some extent. The high level of such families as the Duchesses must, however, have been balanced by a low level in other families.

The graph shows a slight drop if anything in inbreeding between 1825 and 1850. This was a period in which the influence of the best bred herds was diffusing through the breed, as will be brought out later in the discussion of the coefficients of relationship. Such a grading up process would tend to be accompanied by less intensive inbreeding. During the next period, however, a genuine rise of inbreeding is indicated from a study of both the bulls and cows. The change from 18.0 in 1850 to 27.4 in 1875 is more than five times its probable error. This indicates renewed attention to the building up of closely bred families. These families seem to have been based largely on Bates and Booth bred stock. The graph shows that Bates maintained a level of 40 per cent inbreeding in the Duchesses practically up to 1850. On the other hand, little if any of the increase in inbreeding at this time (1850-1875) can be attributed to Champion of England. His blood can hardly have spread far beyond the Sittyton herd by 1875. Paradoxical as it may seem, it is likely that the diffusion of Champion of England blood was responsible for the drop in inbreeding shown by both bulls and cows between 1875 and 1900 (difference 2.6 times its probable error). The first effect of this diffusion was something like that of an outcross with respect to the Bates and Booth topped herds of the time.

We come now to the level of inbreeding in the breed today, viz., 26 per cent. A slight rise over 1900 is shown. As far as any significance can be at-



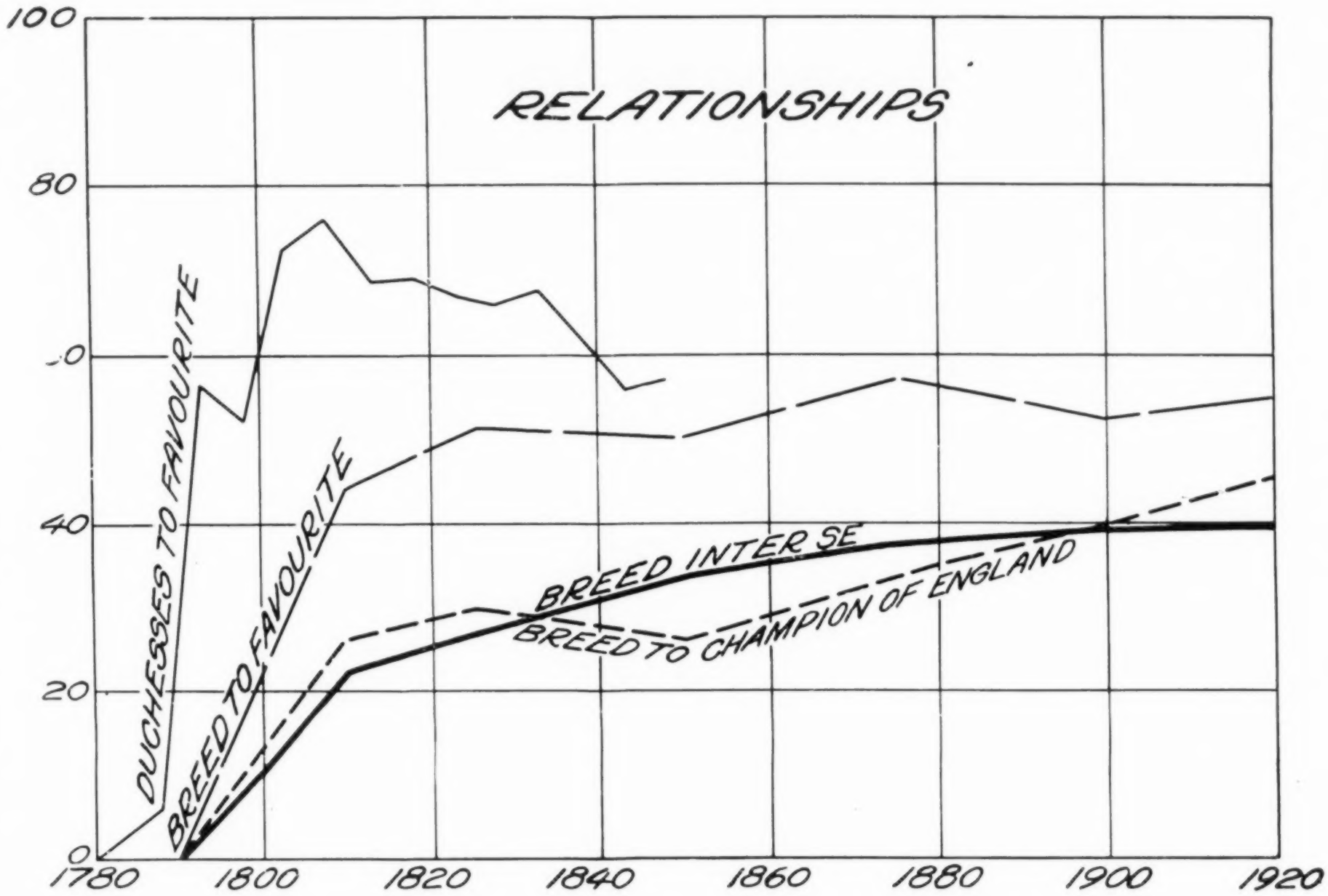
VARIATION IN INBREEDING

Figure 10

The degree of inbreeding of Shorthorn bulls (dotted line), Shorthorn cows (broken line), breed average (heavy solid line), with Bates' Duchesses (light solid line) for comparison. The origin at 1790 is somewhat arbitrary. The coefficient of inbreeding measures the approach toward complete homozygosis. The coefficient of 26 per cent in 1920 means that the breed at that time was 26 per cent less heterozygous than the foundation stock of 1790.

tributed to this rise (difference 1.4 times its probable error) it is to be assigned to the influence of Champion of England.

Twenty-six per cent inbreeding means a correlation of 0.26 between the uniting germ cells in their genetic constitution, relative, of course, to the condition existing in the foundation stock of about 1790. It means also that there has been a loss of 26 per cent in heterozygosis due to inbreeding alone besides that which has probably been accomplished through selection. The real significance of this coefficient can be made clear by comparing it with the results of certain regular systems of mating. If, for example, an entire breed were descended from a single pair of animals chosen at random from the foundation stock, the coefficient of inbreeding would be 25 per cent or practically the same as that of the present day Shorthorns. Again, an entire breed descended from a herd in which an individual sire had been used exclusively for two generations would have an inbreeding coefficient of 28.1 per cent in all later generations, if there were no further inbreeding. In the light of this result the coefficient of 26 per cent for the year 1920 is remarkably high especially considering the large number of animals that are registered every year. How nearly this figure represents the condition of the Shorthorn cattle of the entire world cannot be stated but it is believed that the American, Canadian and Argentinian sections differ but little in this respect from the British whence they were derived.



RELATIONSHIP IN THE SHORTHORN BREED

Figure 11

The relationships between the random individuals of the breed, the breed and Favourite, and the breed and Champion of England at different periods. The relationship between the Bates' Duchesses and Favourite (252) are shown for comparison.

Relationship to Favourite

The evident extensive influence of Colling stock on the breed in this early period makes it important to study intensively the degree of relationship to Charles Colling's most famous sire, Favourite, in all periods up to the present. As shown in Figure 11, the relationship of the whole breed to this bull rises from the basic 0 per cent in 1790 to 44 per cent in 1810 and 51 per cent in 1825. From that time it has shown only minor fluctuations from 50 per cent, being 55 per cent in 1920. These are remarkable figures when it is recalled that 50 per cent is the coefficient which applies to the relationship between parent and offspring in a random bred stock. It means that in so far as unselected characters are concerned the Shorthorn breed of today resembles Favourite slightly more than the average resemblance between sire and son among the old Teeswater stock of his time.

As already noted, this relationship had already risen above 50 per cent by 1825. At this date there was not a uniform diffusion, however, as indicated by the much higher coefficients in the Duchess family, balanced presumably by low coefficients in other strains. Even the Duchesses had practically fallen to the breed level, however, by 1850. It may safely be assumed that by this time such a uniform diffusion of Favourite blood had taken place that no further change is possible.

Relationship to Champion of England

Champion of England, who was dropped in 1859, had an inbreeding coefficient of 18.4 ± 0.56 per cent, or about the same as that of the entire

breed at that time (18.0). His relationship to Favourite was about 49 per cent as compared with 50 per cent for the breed average. The practical identity in this respect is important as showing that no amount of concentration of the blood of Champion of England could appreciably change the breed's relationship to Favourite. His relationship to the breed at the time of his birth was about 26 per cent which is distinctly less than that of two random animals of the breed to each other in the periods preceding or following his birth (34 per cent and 38 per cent, respectively). In the years following, the figure was steadily increased until it was 46 per cent in 1920, an increase of 20 per cent since 1850.

In this connection it is interesting to compare the relationship of Champion of England to the breed with his average relationship to the 20 leading Shorthorn prizewinning sires at the International Livestock Exposition, 1918-22. The latter relationship has been found to be about 47 per cent or only about one per cent higher than the relationship between Champion of England and the breed. Since the coefficient of relationship between an ancestor and his descendants is about the same as percentage of blood, the increase of 20 per cent in relationship to Champion of England since 1850 may be considered as giving approximately the percentage of Champion of England blood in the breed as a whole today. Likewise, the average for the 20 prizewinners may be taken as about 21 per cent. These results are in harmony with Malin's calculation of 22.5 per cent Champion of England blood for these same animals, using complete pedigrees. These figures indicate then that there is no significant difference between the amount of Champion of England blood carried by the prizewinners and the average for the breed as a whole. In other words, this means, as Malin has already suggested, that Champion of England blood has now become so thoroughly diffused throughout the breed that a further concentration is impossible.

The preceding results indicate that Champion of England has been the most potent sire since Favourite in affecting the character of the breed.

The Homogeneity of the Breed

A very important question connected with a breed is the degree of homogeneity. Is it a well knit unit or a collection of diverse tribes? The coefficient of inbreeding does not answer this question. A breed might become split up into several such tribes each closely inbred within itself but having little relationship to each other. Such an assemblage might well show a high coefficient of inbreeding. To take an extreme illustration, a group of pedigrees picked at random from the record books of Shorthorn cattle, Holstein cattle, Percheron horses, Duroc-Jersey hogs, Shropshire sheep and Persian cats might yield a high coefficient of inbreeding with no homogeneity whatever. Returning to the Shorthorns, high coefficients of relationship to particular animals, such as to Favourite and to Champion of England, go farther in indicating breed homogeneity but do not give a complete answer. The most direct method of determining homogeneity is to calculate the degree of correlation between random animals. For this purpose pedigree lines of different animals for a particular year were matched at random using no line more than once. There were 150 such comparisons in 1810, 150 in 1825, and 100 in the later years. The calculated coefficients of relationship are shown in Table III (Breed inter se) and in the heavy line of Figure 11. This figure shows a consistent rise in breed homogeneity. The most rapid rise occurs before 1850 in agreement with the rise in the coefficient of inbreeding.

With such high coefficients of relationship as shown by the table, purely random mating within the breed should give fairly high coefficients of inbreeding. It is easy to calculate the amount

of inbreeding due to random mating. The formula for the interrelationship at a given time in the symbols used in the preceding papers of this series is $R = \frac{\Sigma [(\frac{1}{2}^{n+n^1}(1+F_A)]}{1+F}$

The formula for inbreeding is $F = \Sigma [(\frac{1}{2}^{n+n^1+1}(1+F_A)]$.

The relations $R = \frac{2F}{1+F}$ and $F = \frac{R}{2-R}$ follow immediately. Applying the latter formula we obtain the following figures for the degree of inbreeding resulting merely from random mating within the breed.

Coefficients of Inbreeding

Date	*Due to Random Mating*	*Observed*	*Difference*
1810	12.4	16.6	+4.2
1825	15.5	19.9	+4.4
1850	20.4	18.0	—1.6
1875	23.3	27.4	+4.1
1900	24.4	22.9	—1.5
1920	24.6	26.0	+1.4

These figures indicate that there has been little active inbreeding in the Shorthorns since the foundation period. Some active inbreeding is indicated by the excess in the observed inbreeding of 1810 and 1825, and again in 1875 in agreement with the previous conclusions. As for the breed today, the high correlation between random animals (nearly .40) and the practical identity of the observed inbreeding and that due to random mating for 1900 and 1920, indicates that the breed is now a rather homogeneous unit.

A partial analysis of the ancestry of the 20 leading American prizewinning sires taken from Malin[2] indicates that they do not form a specialized group. Their average inbreeding came out 25 per cent as compared with 26 per cent for the breed average. Their relationship to each other was 39.8 ± 3.4. The average relationship between the breed of 1920 and these sires was 33.0±2.8 per cent. Champion of England and Favourite were related to the prizewinning sires 47.0 and 45 per cent respectively.

Summary

The present study is an attempt to interpret the history of the Shorthorn on the basis of the values of certain Mendelian coefficients. The coefficients of inbreeding measure the decrease in heterozygosis relative to the foundation stock. The changes in the coefficients at different times indicate the prevailing system of mating. The changes in the coefficients of relationship to particular animals, Favourite and Champion of England, measure the influence of these animals on the characteristics of the breed. The correlation between random individuals of the breed measures the amount of homogeneity. Comparisons with the coefficients in a noted early family, the Bates' Duchesses, give suggestions as to the means by which the present condition of the breed was attained.

Prior to 1810, herds with an intense concentration of the blood of one animal, Favourite (252) were built up by the Collings. This concentration of blood was carried on for many years in particular families of which Bates' Duchesses may be taken as an extreme representative. The widespread use of bulls of this stock rapidly raised the whole breed to such a point that there came to be a general resemblance to Favourite equal to that between parent and offspring in the foundation stock, and a correlation between random individuals as great as between half brothers of that stock. This was accompanied by an elimination of 15 to 20 per cent of the heterozygosis originally present. Most of these changes took place before 1825. By 1850 the breed was a fairly homogeneous unit, with the blood of Favourite uniformly diffused. There seems to have followed a period of renewed inbreeding in particular lines, based probably on Bates and Booth stock. Meanwhile, the blood of a bull, Champion of England, equal to the average of the breed

in heredity and relationship to Favourite, but otherwise somewhat apart from the breed as a whole, was being concentrated by Amos Cruickshank. The diffusion of the blood of this bull through the breed between 1875 and 1900, having to a slight extent the effect of a cross, brought down the degree of inbreeding. The homogeneity of the breed as measured by the relationship of random animals remained practically stationary as Champion of England blood, increasing in amount, gradually displaced Bates and Booth blood. The increase in relationship to Champion of England has gone on to the present, until in 1920, the coefficient of 46 per cent is 20 per cent greater than the original relationship to this bull and approaches the present relationship to Favourite of 55 per cent. The relationship of random animals to each other, however, approaches 40 per cent. The present coefficient of inbreeding, 26 per cent, indicates an elimination of more than one-fourth of the heterozygosis of the foundation stock. The indications are that the breed is practically in equilibrium in all of these respects, an equilibrium which can only be disturbed by the formation and diffusion of the influence of a new, closely bred family based on the excellence of a new Favourite or a new Champion of England. The increased size of the breed makes the difficulty of exerting an influence comparable to that of these earlier bulls enormously greater even than it was in Cruickshank's time.

TABLE I. The coefficients of inbreeding of Shorthorn sires and dams at each period.

Year	*No. Animals*	*No. Ancestral Lines*	*Inbreeding Coefficient*	
1810	75 bulls	300	19.1 ± 1.0	16.6 ± 0.7
1810	85 cows	340	14.3 ± 0.9	
1825	50 bulls	200	21.9 ± 1.4	19.9 ± 1.2
1825	50 cows	100	16.1 ± 2.5	
1850	50 bulls	200	18.4 ± 1.3	18.0 ± 1.2
1850	50 cows	100	16.9 ± 2.5	
1875	50 bulls	200	25.9 ± 1.4	27.4 ± 1.3
1875	50 cows	100	29.0 ± 2.6	
1900	50 bulls	200	23.2 ± 1.4	22.9 ± 1.2
1900	50 cows	100	22.6 ± 2.6	
1920	50 bulls	100	25.4 ± 2.7	26.0 ± 2.0
1920	50 cows	100	26.7 ± 2.8	

TABLE II. The leading sires of shorthorn winners at the International, 1918-1922.

	Number Points	Winners		Number Points	Winners
Avondale 245144	490	34	Rodney 753273	136	7
Whitehall Sultan 163573 ...	380	38	Cumberland's Last 229822 .	122	15
Villager 295884	280	22	Fair Acres Sultan 354154..	122	8
Revolution 388359	280	22	Dale Clarion 385195	120	6
Master Ruby 446601	244	9	Sultan Supreme 367161	118	7
Sultan Stamp 334974	214	17	Superb 300054	116	7
Double Dale 337156	182	17	Village Beau 295883	112	14
Archer's Hope 402425	170	9	SanquharDreadnaught680399	108	9
Lespedeza Sultan 406929 ..	156	7	Village Supreme 423865 ..	108	5
Master Bapton 556804	152	3	Maxwalton Pride 367542 ..	96	2

TABLE III. The coefficients of relationship between Favourite and the breed, Champion of England and the breed and between random individuals at each of the periods studied.

Date	*Breed to Favourite*	*Breed to Champion of England*	*Breed Inter Se*
1810	44.3 ± 1.2	26.3 ± 1.2	22.0 ± 2.8
1825	51.3 ± 1.9	29.9 ± 1.6	26.8 ± 2.5
1850	50.1 ± 1.9	26.1 ± 1.6	33.9 ± 3.1
1875	57.6 ± 1.8	32.9 ± 1.5	37.8 ± 3.2
1900	52.1 ± 1.9	39.2 ± 1.6	39.3 ± 3.2
1920	55.2 ± 2.3	45.5 ± 2.3	39.5 ± 3.2

Literature Cited

1. Gowen, John W., and Mildred R. Covell, 1921. Studies in Milk Secretion. XII. Transmitting Qualities of Holstein-Friesian Sires for Milk Yield, Butterfat Percentages and Butterfat. *Maine Agri. Exp. Sta. Bull.* 301.

2. Malin, Donald F., 1923. The Evolution of Breeds. Wallace Publishing Co., Des Moines, Iowa.

3. Pearl, Raymond, 1915. Report of Progress of Animal Husbandry Investigations in 1915. *Paper No.* 92 from the Biological Laboratory of the Maine Agri. Exp. Sta.

4. Pearl, Raymond, John W. Gowen and John Rice Miner, 1919. Studies in Milk Secretion. VII. Transmitting Qualities of Jersey Sires for Milk Yield, Butterfat Percentage and Butterfat. *Maine Agri. Exp. Sta. Bull.* 281.

5. Wallace, Robert, 1923. Farm Live Stock of Great Britain.

6. Wright, S., 1922. Coefficients of Inbreeding and Relationship. *Amer. Nat.* 56: 330-338.

7. Wright, S., 1923. Mendelian Analysis of Pure Breeds of Livestock. I. The Measurement of Inbreeding and Relationship. *Journal of Heredity.* 14:339-348.

8. Wright, S., 1923. Mendelian Analysis of the Pure Breeds of Livestock. II. The Duchess Family of Shorthorns as Bred by Thomas Bates. *Journal of Heredity,* 14:405-422.

9. Wright, S. and Hugh C. McPhee. An Approximate Method of Calculating Coefficients of Inbreeding and Relationship from Livestock Pedigrees. *Journal of Agricultural Research.* In Press.

ELECTROGENETICS

A Review

WITH the establishment during the past year of the first electrogenetic laboratory at Belgirate, Italy, and the proposed establishment of two other similar laboratories in the same country one may well examine the studies prompting such activity, and inquire into the reliability of the data already obtained.

The establishment at Belgirate has both governmental and industrial support and its immediate practical object is to obtain new varieties of fruits through the services and methods of Alberto Pirovano.

The methods of Pirovano have been set forth in an attractively illustrated volume on "the electric mutation of plant species."* These methods are homogeneous in that they all involve the electrical treatment of pollen previous to pollination, yet they offer a lamentable diversity in the particular nature of the electrical treatment, since use is made of radio-active materials, x-rays, ultra-violet rays, electrolytic action, magnetism and high tension electric current, with diverse variations and combinations. Simple devices are described for suitable exposure of pol-

*La mutazione elettrica delle specie botaniche e la disciplina dell eredita nell ibridazione. A. Pirovano. U. Hoepli. Milan. 1922. The book is a substantial volume of some 300 pages containing more than 100 figures and plates.

len to these agencies. Heretofore experimenters in general have found an enduring complexity associated with the relation of any one of these phenomena to living organisms, in view of which fact the implied comprehensiveness of the methods does not prejudice one in their favor at the outset.

The major portion of the experimental data, however, is concerned with the application of a magnetic field to pollen, and there are about one hundred and fifty trials of this sort recorded. This number of trials under a restrained program would seem sufficiently indicative, but we find no attempt at systematic control of field strength maxima, duration of treatment, or cycle. In the first nineteen trials, for example, the same plant was used throughout, but ten different field strength maxima, nine different periods of exposure and three different cycles were used. In addition a further treatment of pollen was given in five cases, one control served for the entire group, and no trials were run in duplicate.

As a result of such experimental procedure one is left without an adequate basis for comparing one experiment with another. In a problem of this sort the variability of the control itself, particularly in the case of hybrids, is by no means a constant, and the definition of the limits of this variability in many cases may constitute a real problem. On the other hand, if a valid control is established and abnormalities are associated with the treatment, this association is still indefinite in the case of these experiments, since the normal variability may be influenced by such factors as the drying out of the pollen and its age at the time of pollination.

In this connection it may well be noted that the illustrations are misleading in that they fail to indicate the true range of variability associated with the use of normal pollen. Finally, the types of variation obtained, and attributed by Pirovano to the influence of the electrical agencies, are of the sort ordinarily associated with hybridization, while the frequency of these variations is not clearly established as having been modified.

The plants used in these experiments were all annuals, and included species of Papaver, Cheiranthus, Helianthus, Althea, Cucurbita, Lunaria, Solanum Brassica, and Pisum. No experimental data for any of these plants appears sufficiently convincing to establish the fact of abnormal variation, let alone the definite association of such variations with electrical influences.

While the advisability of establishing an electrogenetic laboratory previous to the presentation of more convincing data may perhaps be questioned, nevertheless it is to be hoped that the work of the new electrogenetic laboratory may clear up the apprehensions arising from Pirovano's publication on electrogenetics, and by following a less pretentious and more carefully controlled program may be of real assistance in the development of the science of genetics.

L. H. Flint.

Back Numbers of the Journal of Heredity Wanted

Numbers listed below should be mailed to the office of the Association, Victor Building, 724 Ninth St. N. W., Washington, D. C., and will be paid for at the prices indicated. Unless payment in cash is requested, members' accounts will be credited with the amounts due for the Journals received from them.

Vol. V, Nos. 1, 4 and 7, 50c.
Vol. IX, No. 6, 30c.
Vol. XI, Nos. 1, 2, and 4, 30c.

American Breeders Magazine:

Vol I, No. 3, 50c.
Vol. II, No. 1, 50c.
Vol. III, No. 4, 80c.
Vol. IV, No. 3, 50c.

THE POTATO OF ROMANCE AND OF REALITY

III. Introduction of the Potato Into Culture

W. E. Safford

FOR more than a century *Solanum tuberosum* continued to be grown as a curious exotic plant in gardens both in England and on the Continent, before it began to attain a reputation as a food staple. Its value was first recognized in Ireland, where conditions of soil and climate were peculiarly favorable for its propagation. An illustration after a painting by Francis Walker, of a mother and daughter digging potatoes in County Donegal, was published in Frank Matthews' *Ireland* (Edition of 1912). The surrounding landscape in this lovely picture suggests the coast islands of Southern Chile where both Drake and Cavendish found the potato extensively cultivated in the sixteenth century, as related in the first part of this paper. Not only do the Irish and Chilean habitats resemble each other but the climates of the two regions are also similar; that of Southern Chile, influenced by the Humboldt Current which sweeps northward along the coast, that of Ireland by the beneficient Gulf Stream which tempers the climate of the islands and shores of the western coast.

It was the Irish peasants who first took up the cultivation of the potato, and it soon became their only food crop, serving for breakfast, dinner, and supper. Their affection for it is shown by many pet epithets, including the "flowery potato," and the "laughing potato." The simplest form in which it was eaten by them was baked or boiled and dipped in a saucer of salted milk. Between meals the children were allowed to roast potatoes on their own account in the turf or wood ashes. It was a common sight in passing a cottage to see a group of little ones run to the door, each with a roasted potato in his hand. While they lasted there was no dearth of wholesome food. When the supply was exhausted it was necessary to buy oatmeal which was made into a sort of pudding or thick porridge called "stir-about." Potatoes served as food also for the family pig, the dog and a few fowls. The poor had little else except perhaps buttermilk at breakfast and supper. If the family possessed a cow, there was also butter which was used for frying delicious potato cakes. It was not long before the Irish learned to use potatoes as a source of whiskey, in the preparation of which they reduced the potatoes to a paste or pulp, added yeast and, after it had undergone a process of fermentation, distilled it into a clear alcoholic liquor which was called "poteen" from the small pots used in the process.

From its skin they prepared a soup and they used the water in which potatoes are boiled as a curative wash for sprains and broken limbs. Perhaps the most delicious potato preparation of all was that called "pardy" or "cal-carron," made from new potatoes. For the Irish the potato acquired an almost sacred significance, as the daily bread which they received in answer to their prayers.

In certain localities it was customary at the time of planting for the parish priest to march solemnly to the field and bless it, praying for a bountiful harvest. The potato, however, was not an unmixed blessing to Ire-

land. Though it yielded an abundant return for little labor, yet the occasional failure of the crop caused unspeakable misery to the people, for in their economy it had taken the place of oatmeal and all other foods.[1]

By whom and when the potato was introduced into Ireland is not definitely known, but we know that it was cultivated there as a field crop before 1663, a year of dearth in Great Britain and Ireland. In March of that year the attention of the Royal Society was called to it as a crop of national importance by Mr. Buckland, a Somersetshire gentleman, and such members of the Society as had lands adapted to its culture were entreated to plant the new vegetable. The recommendation was reported favorably by a committee to whom it was referred, and Mr. Evelyn, the celebrated practical gardener of that period, was requested to enforce the Society's opinion in the *Sylva,* then published under the Society's auspices. It is evident that it found no favor with him for in 1664 in his *Kalendarium Hortensi,* the first Gardener's Calendar published in Britain, he gives the following advice: "Plant potatoes in February in your worst ground." In 1664, before the *Sylva* appeared, there was published the first pamphlet advocating the cultivation of the potato in England. It bears the following prolix title: "England's happiness increased, or a sure and easy remedy against all succeeding dear years by a plantation of the roots called potatoes, whereof (with the addition of wheat flour) excellent, good, and wholesome bread may be made every year, eight or nine months together, for half the charges as formerly. Also, by the planting of these roots 10,000 men in England and Wales, who know not how to live or what to do to get a maintenance for their families, may, off one acre of ground, make £30 per annum. Invented and published for the good of the poorer sorts by John Forster, Gent., of Harslop, in Buckinghamshire." The author identifies the potatoes recommended as *Irish potatoes,* declaring that "these roots, although they came at first from the Indies, yet prosper well in Ireland, where there are whole fields of them, from whence they have been brought into Wales and the north parts of England, where they likewise prosper and increase exceedingly."

After recommending methods for their cultivation, Forster gives directions for making potato bread, potato biscuits, potato pudding, potato custards, and potato cheese cakes. He declares that in good ground there will be a yield of three or four heaped bushels per rod, for which no one will grudge a shilling per bushel. Treating the propagation of potatoes as a political measure, he earnestly recommends the King, Charles II, to order potatoes to be imported from Ireland; that every man in every parish shall grow an acre or two; and suggests that out of every £30 worth grown in a parish, £5 shall be paid as tribute to the King.

Notwithstanding the publication of this earnest appeal and its endorsement by the Royal Society, the introduction of the potato as a field crop was extremely slow. Before 1699 potatoes had been introduced into Lancashire, where they became very common. It was from Lancashire and Ireland that they were carried to the British West Indies in the early part of the eighteenth century and were propagated in the mountains of Jamaica under the name Irish potatoes, and from Lancashire also they began to spread over England. They were mentioned slightingly in publications early in the eighteenth century. Loudon and Wise, in the seventh

[1]For most of this information I am indebted to the Rev. John J. Queally, Rector of the Church of the Transfiguration, Washington, D. C.

edition of their "Compleat Gardener" published in 1719 did not even mention the potato, and as late as 1770 it was not known generally in the southwestern counties.

In Scotland potatoes were first cultivated as a field crop in 1739, but were not known in the Highlands until 1743. Although their culture by the cottagers was successful they did not meet with favor among the higher classes, while zealous Presbyterians looked at them askance, declaring that potatoes are not mentioned in the Bible. It was not until they were urged by hunger that the Scotch seriously took up the cultivation of the potato and became convinced of its excellent qualities.[2]

The Potato in Prussia and France

Everyone knows the story of the introduction of potato culture into Prussia, which Frederick the Great and his eccentric father were so active in accomplishing. It has recently been told anew in a paper read before the second Potato Congress held at Breslau in October, 1923, by E. Duczek.[3] The important part which the potato has assumed in the economy of the German people is indicated in this article by the preliminary prayer: "Unser taeglich Brot, gib uns Heute!"—and the reverence felt for the beneficent autocrat is expressed at the end in a beautiful tribute to "Fridericus Immortalis." In preparing his paper, Duczek had access to documents in the archives at Breslau, many of them faded and yellow with age, in which potatoes figure under the names *Kartoffeln*, *Tartoffeln*, and the quaint hybrid combination *Erdtoffeln*. Like all of his predecessors in potato literature, he begins with the Drake, Hawkins and Heriot myths and the story of the disgruntled gardener—whether Raleigh's or Drake's, he does not specify.

He then goes on to tell the story of the introduction of the potato into his native province, pointing out that it was first cultivated at Breslau in the garden of Dr. Laurentius Scholtz. This celebrated garden, already referred to as the source of the potatoes used by Bauhin for his illustrations, was reproduced as faithfully as possible in honor of the Potato Culture Exposition of 1913 at Breslau. The first active measures taken for the introduction of the potato into Prussia were those of the great Elector, Frederick William, who in 1651 caused potatoes to be planted in the Berlin Lustgarten. In Figure 12 the Grosser Kurfuerst is shown with his consort inspecting the potatoes planted by his orders. His grandson, King Frederick William I, in his effort to foster potato culture, resorted to drastic steps, threatening to cut off the noses and ears of all who refused to plant them. He also decreed that they should be fed to the poor inmates of the Berlin Charitee and presented to the Hospital a piece of land to be used solely for their cultivation; but the real credit for promoting potato culture in Prussia, especially in Silesia and Pomerania must be awarded to his illustrious son, Frederick the Great. In the year 1744 Frederick II caused seed potatoes to be gratuitously distributed and compelled the peasants to cultivate them. In Figure 13 Frederick the Great is seen inspecting a field of potatoes planted by his orders. Not only were edicts and ordinances issued, but the local authorities were warned that their duties did not cease with the promulgation of the decrees.

[2]For much of the foregoing information relating to the introduction of the potato into Ireland and Great Britain I am indebted to a monograph entitled "The Potato: Its culture, Uses and History," by George W. Johnson. London, 1847.

[3]See Zeitschrift der Landwirthschaftskammer Schlesien. Kartoffel nummer. 27 Jahrgang, p. 1152. Oct. 27, 1923.

For this publication I am indebted to Dr. Otto Appel, Direktor der Biologischen Reichsanstalt fuer Land u. Forst Wirthschaft, Berlin—Dahlem; also for the number of March 15, 28 Jahrgang, 1924.

Die kurfürstliche Familie bei den ersten Kartoffelpflanzungen.

POTATOES A CURIOSITY

Figure 12

The Great Elector, Frederick William, with his consort, inspecting the potatoes planted by his order in the Berlin Lustgarten. Not until the reign of his great-grandson, Frederick the Great, did the potato become a popular food staple in Prussia. Photograph of etching by Ebner, received through the courtesy of Dr. Appel.

FREDERICK THE GREAT

Figure 13

Visiting a potato field planted in obedience to his decree. Frederick and his father tried to encourage the use of potatoes in Prussia by making their culture compulsory, with severe penalties for failure to comply. These measures did not meet with very marked success, but the famine which followed the Seven Years War finally did what Frederick's laws failed to do. Photograph of painting by Wartmuller, received through the courtesy of Dr. Appel.

They were held responsible for their practical enforcement through the aid of the land dragoons, and were expected to make official reports from time to time setting forth the condition of potato plantations in their districts and the zeal shown by the peasants in cultivation of the crop.

In the Breslau archives Herr Duczek found two original royal circulars, the first dated March 24, 1756, the second, April 5, 1757; both of them showing remarkable familiarity on the part of Frederick the Great with the best methods of potato culture. In the second circular, which was published in full in a later number of the Breslau *Zeitschrift*, the King advises that potatoes be planted in the dark of the moon. He also indicates the proper time of plowing, manuring, and planting the fields, cautioning the farmers that if they plant small potatoes they will raise small potatoes, while the best results will follow from the selection of large tubers which should be so cut as to leave an eye in each piece. He also instructs them how to keep potatoes in straw-lined pits, through the winter, and that although potato patches do not need the same protection from cattle and sheep as grain fields, yet care should be taken not to herd swine in their neighborhood. After digging them, at Michaelmas, the hogs need no longer be kept away, but may be allowed to rush in and eat their fill of the tubers left in the ground. The circular ends with various recipes for the preparation of potatoes as food for both man and beast.

These circulars, enforced by local officials, had their effect, but it was famine, caused by the Silesian wars, especially the Seven Years War, which established potato culture in Prussia on a firm basis.

The introduction of potatoes into France was largely due to the cele-

Aussi, en 1766, devenu pharmacien aux Invalides, en préconisait-il la culture. Au cours de la famine de 1769, appréciant l'occasion belle pour mettre en évidence les avantages du précieux tubercule, il invita Franklin, Lavoisier et d'autres illustres personnages a un grand dîner qui fut trouvé exquis bien qu'on n'y eût servi que des pommes de terre!

Mais alors, il se trouva des agronomes, des Savants de l'Institut, pour déclarer que, sans doute, la pomme de terre était un excellent légume, mais que sa culture serait impossible et dangereuse en ce qu'elle appauvrirait tous les terrains où on la pratiquerait et que, par là, elle serait la ruine du Pays!

Pauvres savants!

Mais, la nuit venue, les gardes avaient ordre de se retirer: et alors une grande quantité de gens, attirés par l'attrait du fruit défendu, venaient en cachette voler des pommes de terre pour les planter dans leur propre jardin ou les manger. C'était précisément ce que voulait le bon Parmentier!

Quand toute sa plantation des Sablons fut en fleurs, Parmentier fit un gros bouquet et le porta à Versailles. Le roi mit une des fleurs à sa boutonnière et toute la cour en fit autant. C'était le plus bel hommage qu'on pût rendre aux efforts de Parmentier: de ce jour, la pomme de terre était acceptée sans retour.

INTRODUCTION OF THE POTATO INTO FRANCE

Figure 14

Scenes portraying the measures taken by Parmentier to introduce potato culture into France. Parmentier's method of guarding his potato fields to develop the "forbidden fruit complex" is an interesting contrast to the efforts of Frederick the Great to force potatoes down his subjects' throats. From a series of colored woodcuts entitled L'Historie de la Pomme de Terre, issued by Pellerin & Cie.

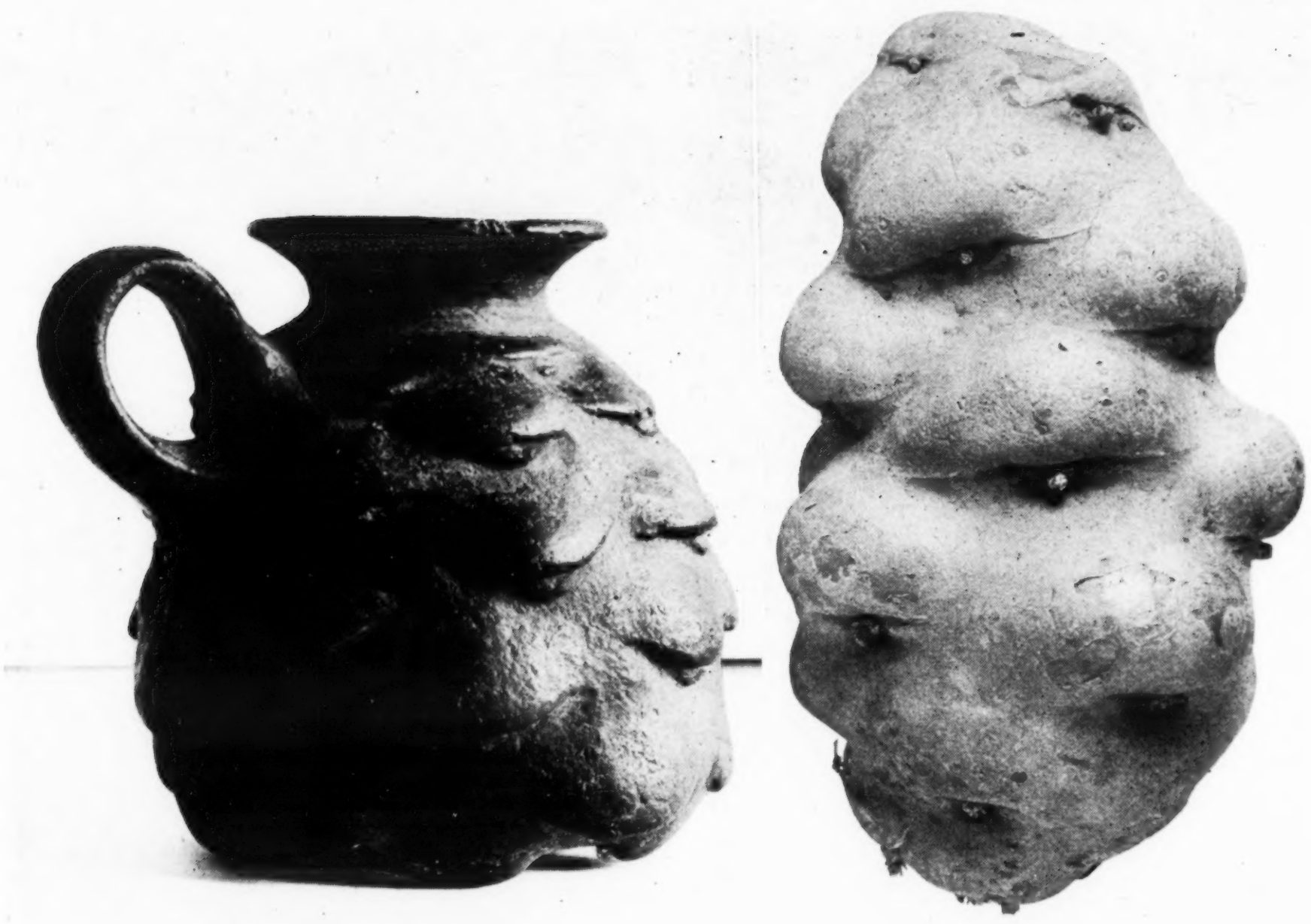
brated Antoine Auguste Parmentier, who, while a prisoner in Germany, during the Seven Years War, was fed upon potatoes and learned to like them. He was then serving as pharmacist in the Hanover army and during his hours of captivity he conceived the idea of introducing potato culture on a grand scale into his own country. Potatoes had hitherto been in bad repute in France owing to the attacks made upon them by physicians who declared that they were poisonous and were the cause of many maladies. The accompanying illustrations (Figure 14), taken from a set of colored woodcuts published in a series of educational pictures, called the *Scric Encyclopédique* Gluq, des Lecons des Choses Illustrées, tell the story of Parmentier's success. After his return to France, while serving as pharmacist at the Invalides, he entertained Benjamin Franklin, Lavoisier and other distinguished guests with a great dinner at which the bill-of-fare consisted entirely of potatoes served in various ways. Yet there were still learned agronomists who declared that although the potato might be a good vegetable it would be dangerous to introduce it, for it would ruin the soil wherever it was planted. Then Parmentier, to prove the falsity of these assertions, obtained from Louis XVI. permission to plant potatoes in a piece of land called *Les Sablons*, notorious for its sterility. When in a short time the potatoes sprouted and this field, which hitherto had been known only as a sandy waste, assumed the appearance of a blooming garden, people began to believe that Parmentier was right. In order to forward his ends he caused his potato plantation to be guarded by soldiers in full uniform throughout the day, under the pretext of preventing depredations; but at night the guard was withdrawn, whereupon a number of people, allured by the attraction of forbidden fruit, came secretly to steal potatoes, to plant them in their own gardens or to eat them. This was the very object which the good Parmentier had in view. When the plantation at *Les Sablons* was in full bloom Parmentier made a great bouquet of potato blossoms which he carried to Versailles and presented to Louis XVI. The King placed one of the flowers in his buttonhole and in the evening Marie Antoinette appeared with a cluster in her hair. This was sufficient: all the court followed the example of their sovereigns. In graciously accepting Parmentier's offering, the King said: "France will thank you some day for having found bread for the poor."

No statue has been erected in Parmentier's honor, but on his grave in the cemetery of Père Lachaise potatoes bloom each year, showing that he has not been forgotten by the people of France. The last picture of the series, representing a maid serving potatoes to her master and mistress, suggests that the name of *la pomme de terre* should be changed to *la parmentière*, in memory of him who brought it to France. In botanical literature his name is perpetuated by the genus Parmentiera, applied to certain American trees belonging to the Bignonia family.

The Potato in North America

Instead of having been taken from North America to Great Britain and Ireland, as set forth in the myths regarding the "Virginia potato," *Solanum tuberosum* was first brought from Ireland to North America, where it is known as the "Irish potato." This happened in 1719, when a colony of Scotch-Irish immigrants established a settlement at Londonderry, Rockingham County, New Hampshire, bringing with them potatoes and flax. Hazlett, in his history of Rockingham County, gives the following account of this settlement:

"The first crops raised by the emigrants were potatoes and flax. They had brought their seed and spinning wheels from Ireland and were the first to cultivate the potato and manufacture linen in New England. They appear



PREHISTORIC AND MODERN POTATOES

Figure 15

A funeral vase in the form of a conventionalized potato belonging to the variety called *papa amarilla*. From a pre-Columbian grave at Chimbote, Peru.

A modern specimen of *papa amarilla*, or yellow potato, a variety with projecting eyebrows. Notice the similarity between the ancient and modern forms. Collected by W. F. Wight.

to have cultivated land in common the summer after their arrival, as there is a tract known by the name of the 'Common Field,' containing about two and one-half acres and situated a few miles west of the dwelling house of Mr. Jonathan Cate in Derry. It was undoubtedly a clearing, and may have been an abandoned planting ground of the Indians who were gradually retiring to deeper shades of the wilderness in the wilds of Canada."[4]

A more detailed description, with perhaps a flavor of romance, is given by Parker in his "History of Londonderry." Describing the arrival of the settlers of this town he says:

"They introduced the culture of the potato, which they brought with them from Ireland. Until their arrival, this valuable vegetable, now regarded as one of the necessities of life, if not wholly unknown, was not cultivated in New England. To them belongs the credit of its introduction to general use. Although highly prized by this company of settlers, it was for a long time but little regarded by their English neighbors: a barrel or two being considered a supply for a family. But its value as food for man and for beast became at length more generally known, and who can now estimate the full advantage of its cultivation to this country? The following well-authenticated fact will show how little known to the com-

[4]Hazlett, Charles A. History of Rockingham County, N. H. Page 506. 1915.

munity at large the potato must have been. A few of the settlers had passed the winter previous to their establishment here, in Andover, Mass. On taking their departure from one of the families, with whom they had resided, they left a few potatoes for seed. The potatoes were accordingly planted, came up and flourished well; blossomed and produced balls, which the family supposed were the fruit to be eaten. They cooked the balls in various ways, but could not make them palatable, and pronounced them unfit for food. The next spring, while ploughing their garden, the plough passed through where the potatoes had grown, and turned out some of great size, by which means they discovered their mistake."[5]

It is not the province of this paper to follow the development of potato culture in the United States. For this the reader is referred to the admirable monograph on the potato by William Stuart of the U. S. Department of Agriculture, who treats of its culture, uses, history and classification.

Search for the Wild Form

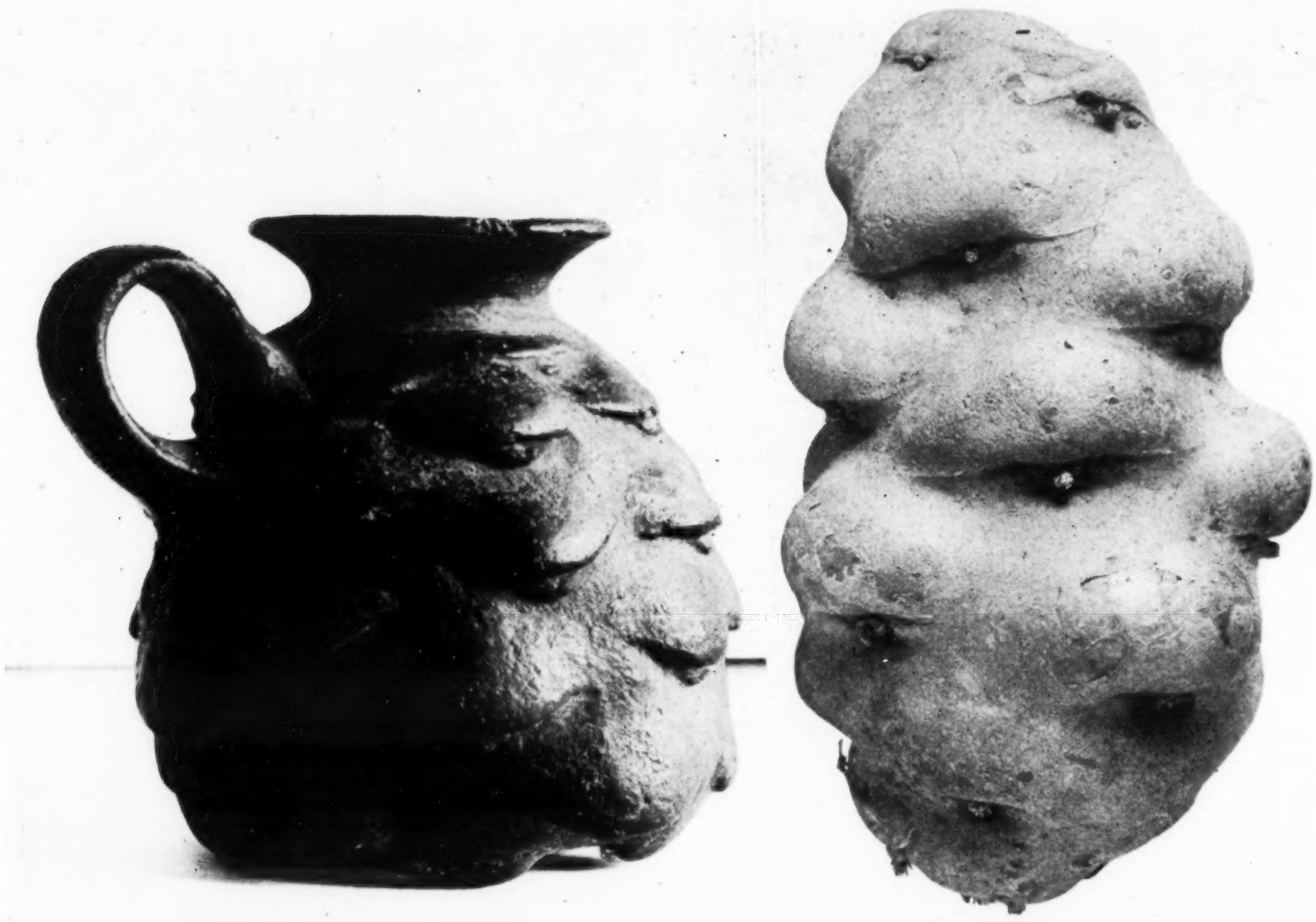
In endeavoring to trace its botanical origin, repeated announcements of the discovery of the wild ancestor of *Solanum tuberosum* have been made. Darwin, in January, 1835, found wild potoes growing on the islands of the Chonos archipelago, southern Chile, occurring in great abundance near the sea beach. In his journal, under date of January 7, he says: "The tallest plant was four feet in height. The tubers were generally small, but I found one of an oval shape two inches in diameter; they resembled in every respect, and had the same smell as English potatoes, but when boiled they shrunk much, and were watery and insipid, without any bitter taste. They are undoubtedly here indigenous: they grow as far south, according to Mr. Low, as latitude 50 degrees, and are called *aquinas* by the Indians of that part; the Chilotan Indians have a different name for them. Professor Henslow, who has examined the dry specimens which I brought home, says that they are the same with those described by Mr. Sabine from Valparaiso, but that they form a variety which by some botanists has been considered specifically distinct." Lindley, after a study of the evidence, believed that *Solanum tuberosum* grew wild in Chile and declared that the specimens grown in the garden of the Horticultural Society of London to be "no more distinguishable from our cultivated varieties than they are from each other." He also regarded wild tuber-bearing Solanums collected in Mexico as belonging to the species *Solanum tuberosum.* Subsequent study of this group of Solanum, however, proved definitely that Darwin's wild potato was not *Solanum tuberosum,* but a distinct species which was named *Solanum maglia* by Schlechtendahl, the specific name being the Italian orthography of the vernacular *malla,* by which the Indians distinguished the wild tuber-bearing species from the cultivated *Solanum tuberosum,* called *poni* or *ponu.* All of these names in the dialect of the Indians of southern Chile are naturally quite distinct from the Quichuan name *papas.*

It is impossible, in this paper, to review the literature relating to wild tuber-bearing species of Solanum. Among the writers of recent years who have given the subject serious consideration are Dr. George Bitter of Bremen,[6] Mr. W. F. Wight of the Bureau of Plant Industry, who in 1913 visited Western South America in a search for the wild ancestor of the potato,[7] and Dr. Per Axel Rydberg of the New

[5]Parker, Edward L. The History of Londonderry. Pages 48 and 49. 1851.

[6]Bitter, G. Solana Nova, vel minus cognita, in Fedde's Repertorium Spp. Nov. vols. 10, 11, 12, 13. 1912-1914.

[7]Wight, W. F. Origin, Introduction and Primitive Culture of the Potato, in *Proceedings of the third Annual Meeting of the Potato Asso. of America,* p. 35. 1916.



PREHISTORIC AND MODERN POTATOES

Figure 15

A funeral vase in the form of a conventionalized potato belonging to the variety called *papa amarilla.* From a pre-Columbian grave at Chimbote, Peru.

A modern specimen of *papa amarilla,* or yellow potato, a variety with projecting eyebrows. Notice the similarity between the ancient and modern forms. Collected by W. F. Wight.

to have cultivated land in common the summer after their arrival, as there is a tract known by the name of the 'Common Field,' containing about two and one-half acres and situated a few miles west of the dwelling house of Mr. Jonathan Cate in Derry. It was undoubtedly a clearing, and may have been an abandoned planting ground of the Indians who were gradually retiring to deeper shades of the wilderness in the wilds of Canada."[4]

A more detailed description, with perhaps a flavor of romance, is given by Parker in his "History of Londonderry." Describing the arrival of the settlers of this town he says:

"They introduced the culture of the potato, which they brought with them from Ireland. Until their arrival, this valuable vegetable, now regarded as one of the necessities of life, if not wholly unknown, was not cultivated in New England. To them belongs the credit of its introduction to general use. Although highly prized by this company of settlers, it was for a long time but little regarded by their English neighbors: a barrel or two being considered a supply for a family. But its value as food for man and for beast became at length more generally known, and who can now estimate the full advantage of its cultivation to this country? The following well-authenticated fact will show how little known to the com-

[4]Hazlett, Charles A. History of Rockingham County, N. H. Page 506. 1915.

munity at large the potato must have been. A few of the settlers had passed the winter previous to their establishment here, in Andover, Mass. On taking their departure from one of the families, with whom they had resided, they left a few potatoes for seed. The potatoes were accordingly planted, came up and flourished well; blossomed and produced balls, which the family supposed were the fruit to be eaten. They cooked the balls in various ways, but could not make them palatable, and pronounced them unfit for food. The next spring, while ploughing their garden, the plough passed through where the potatoes had grown, and turned out some of great size, by which means they discovered their mistake."[5]

It is not the province of this paper to follow the development of potato culture in the United States. For this the reader is referred to the admirable monograph on the potato by William Stuart of the U. S. Department of Agriculture, who treats of its culture, uses, history and classification.

Search for the Wild Form

In endeavoring to trace its botanical origin, repeated announcements of the discovery of the wild ancestor of *Solanum tuberosum* have been made. Darwin, in January, 1835, found wild potoes growing on the islands of the Chonos archipelago, southern Chile, occurring in great abundance near the sea beach. In his journal, under date of January 7, he says: "The tallest plant was four feet in height. The tubers were generally small, but I found one of an oval shape two inches in diameter; they resembled in every respect, and had the same smell as English potatoes, but when boiled they shrunk much, and were watery and insipid, without any bitter taste. They are undoubtedly here indigenous: they grow as far south, according to Mr. Low, as latitude 50 degrees, and are called *aquinas* by the Indians of that part; the Chilotan Indians have a different name for them. Professor Henslow, who has examined the dry specimens which I brought home, says that they are the same with those described by Mr. Sabine from Valparaiso, but that they form a variety which by some botanists has been considered specifically distinct." Lindley, after a study of the evidence, believed that *Solanum tuberosum* grew wild in Chile and declared that the specimens grown in the garden of the Horticultural Society of London to be "no more distinguishable from our cultivated varieties than they are from each other." He also regarded wild tuber-bearing Solanums collected in Mexico as belonging to the species *Solanum tuberosum*. Subsequent study of this group of Solanum, however, proved definitely that Darwin's wild potato was not *Solanum tuberosum*, but a distinct species which was named *Solanum maglia* by Schlechtendahl, the specific name being the Italian orthography of the vernacular *malla*, by which the Indians distinguished the wild tuber-bearing species from the cultivated *Solanum tuberosum*, called *poni* or *ponu*. All of these names in the dialect of the Indians of southern Chile are naturally quite distinct from the Quichuan name *papas*.

It is impossible, in this paper, to review the literature relating to wild tuber-bearing species of Solanum. Among the writers of recent years who have given the subject serious consideration are Dr. George Bitter of Bremen,[6] Mr. W. F. Wight of the Bureau of Plant Industry, who in 1913 visited Western South America in a search for the wild ancestor of the potato,[7] and Dr. Per Axel Rydberg of the New

[5]Parker, Edward L. The History of Londonderry. Pages 48 and 49. 1851.

[6]Bitter, G. Solana Nova, vel minus cognita, in Fedde's Repertorium Spp. Nov. vols. 10, 11, 12, 13. 1912-1914.

[7]Wight, W. F. Origin, Introduction and Primitive Culture of the Potato, in *Proceedings of the third Annual Meeting of the Potato Asso. of America*, p. 35. 1916.

York Botanic Garden. Dr. Bitter points out that the problem of the origin of our cultivated potatoes is, in spite of many investigations, still unsolved, and that we know nothing definite concerning its original form before it was brought into cultivation by the Arauco Indians of southern Chile and the Incas of Peru. We do not even know whether it proceeded from a single species which has greatly varied under cultivation or whether it resulted from hybridization of several allied species. That certain characters of our cultivated potatoes should be attributed to selection of the best tuber-bearing varieties through a long period of cultivation in situations differing from one another in soil and climate, there can be no doubt. New varieties are constantly appearing, produced by horticulturists through a process of cross-pollination and selection, in the same manner as many other cultivated plants. That even at a very early date varieties had been developed is indicated in the accompanying figures, showing the yellow potato, the most highly esteemed of all varieties, represented in a pre-Columbian funeral vase (See Figure 15). Experiments are also being made by investigators in cross-pollinating distinct wild species with one another and with the cultivated potato which may result in types resembling the original form of the ancestor or ancestors of the potato. Such experiments are now being made at Presque Isle, Maine, by Mr. C. F. Clarke of the Bureau of Plant Industry, in connection with studies in the cytology of the species by Dr. A. B. Stout.

It is not possible to speak in detail of Dr. Bitter's work, but he calls attention to the confusion by early American botanists of our own southwestern *Solanum fendleri* and *Solanum jamesii*, two very distinct species, the former with elliptic or ovate leaflets and vorbicular corolla only slightly notched between its lobes, the latter with jasmine-like foliage and star-shaped flowers. Asa Gray believed *Solanum fendleri* to be a wild variety of the common potato and named it *Solanum tuberosum boreale*. As in other Solanaceue, the flowers of *Solanum fendleri* may be of different colors. The original type specimens had corollas of a deep violet color, and Bitter, retaining the name *Solanum fendleri* for this form, separated from it the white-flowered form under the name *Solanum boreale*, believing the latter to be specifically distinct and adopting Asa Gray's varietal name for it. Rydberg, however, has recently pointed out that the color of the corolla has little significance, but varies considerably, white-flowered specimens being quite as common as those with purple or bluish shades, while other characters, such as hairiness and color of the leaves, are by no means constant.[8]

Wight, returning from his long expedition in South America with a multitude of specimens and from Europe with photographs of herbarium types of various species, including the very specimens collected by Darwin in the Chonos archipelago, makes the following declaration: "Every reported occurrence of wild *Solanum tuberosum* that I have been able to trace to a specimen, either living or preserved in the Herbarium, has proved to be a different species. In fact, so far as the herbarium material is concerned, I have not found in any of the principal European collections, a single specimen of *Solanum tuberosum* collected in an undoubtedly wild state. After a century and a half of intermittent collecting, there is no botanical evidence that the species is now growing in its original indigenous condition anywhere. . . . So far as the number and relationship of the species referred to the section Tuberarium are concerned, the evidence is favorable to the central Andean region."[9]

[8]Rydberg, P. A. The Section Tuberarium of the genus Solanum in Mexico and Central America, in *Bulletin of Torrey Botanical Club*, 51, pp. 146-154 and 167-176. 1924.

[9]Wight, Op. Cit. 37, 38. 1916.

DEEP-EYED POTATOES
Figure 16

Two specimens of yellow potatoes collected at Lima, Peru, in 1915, by Mr. O. F. Cook.

In 1891-92, while acting as World's Fair Commissioner to Peru and Bolivia, the writer made a special study of the food plants of the elevated plateau surrounding Lake Titicaca. At Puno on the shore of the Lake I found in the open plaza market, not only fresh and dried potatoes but a number of other edible tubers belonging to distinct botanical families, among them *oca*, the tubers of *Oxalis*

A FUNERAL VASE
Figure 17

A funeral vase of red terra cotta representing a variety of potato with deep eyes. In the Peabody Museum, Harvard University.

tuberosa, a plant allied to our common wood sorrel, which in Bolivia the Aymara call *apillas; maxua* or *masua; (Tropaeolum tuberosum*, allied to our ornamental garden "nasturtiums," which I afterwards encountered in Bolivia, bearing the name *ysanyo;* and *ulluca* (*Ullucus tuberosus*) a plant related to the cultivated "Madeira vine" called *ulluma* by the Aymaras of Bolivia and *papa lisa* or "smooth potato" by the Spaniards on account of their resemblance to potatoes. Indeed the resemblance of the latter is so close to certain varieties of potatoes that photographs of them were filed with those of *Solanum tuberosum* in the Office of Foreign Seed and Plant Introduction, United States Department of Agriculture. In the elevated Collao the tubers of all of these plants are preserved by freezing and drying in the same way as those of *Solanum tuberosum.*[10] The natural conditions which caused similar specialization of these unrelated plants

[10]For beautiful illustrations of the tubers of *Oxalis, Ullucus, Tropaeolum* and other plants of this region, see Cook, O. F., Peru As a Center of Domestication, *Journal of Heredity*, 16:95-110, March, 1925.

TWO BOLIVIAN VARIETIES

Figure 18

The variety with very deep eyes is known as *petiguilla* or *pitiguinya*. The smooth variety somewhat resembles the sweet potato in shape, and is called *sacco* or *socco* at La Paz. It closely resembles the *cacha blanca* cultivated on the island of Chiloe, Southern Chile. Potatoes received by the office of Foreign Seed and Plant Introduction from Sr. M. V. Ballivian of La Paz, Bolivia.

point to a common center of development. It is a well-known fact that a remarkable similarity is found among unrelated plants in regions characterized by periods of drought, continuous aridity, or great elevation, as in the case of the spiny plants of our Western deserts and the stunted, small-leaved and deep-rooted plants of the high Alps and Andes."[11]

Even the most unusual forms of edible potatoes collected by Mr. Wight and by Mr. O. F. Cook in Chile and Peru, including the deep-eyed yellow potato, and other forms like those shown in the accompanying illustrations (Figures 16 and 17) can not be separated botanically from *S. tuberosum,* and it is interesting to note the very close similarity between varieties growing on the islands of Chiloe, southern Chile, and La Paz, Bolivia.

As I have already said, *Solanum tuberosum* was not found in cultivation in Mexico by Cortez and his companions: It is not even mentioned by early writers on Mexico. Its absence from Mexico seemed remarkable to Humboldt, who, accepting as true the myth of its introduction into England from Virginia, could not understand how it had skipped Mexico in extending its range to North America. In the lists of plants collected in Mexico in recent times *Solanum tuberosum* is recorded as having been found in various localities, including the Federal District surrounding the capital city, and the states of Jalisco, Durango, and Nuevo Leon. All of these specimens proved to be species distinct from *Solanum tuberosum,* with the exception of a few plants which had in all probability escaped from cultivation. They have been described as new species by Bitter and Rydberg.

Summary

From the evidence presented in this paper the following summary may be made:

I. The statement that the potato was found growing in North America by the English colonists and carried thence to England, for which Gerard is responsible, is not true; the *openawk* of the Algonquin Indians with which it was confused by early writers is a tuber-bearing climber of the Bean family, the *Glycine apios* of Linnaeus.

II. The story of its introduction into Ireland by Sir Walter Raleigh is a myth invented in **1693**, more than a hundred years after the return of his ill-fated colony from Roanoke Island. The Drake myth which was substituted for it is equally without foundation.

III. The cultivation of *Solanum tuberosum* in pre-Columbian times extended from southern Chile along the Andes and the highlands of Peru and Bolivia to the mountains of Ecuador and Columbia, but did not reach the shore of the Caribbean Sea. The "potatoes" encountered on the shore and islands of that sea by early navigators were sweet potatoes.

IV. It was carried to Europe from South America by the Spaniards soon after **1580**, thence to Italy and in **1588** reached Charles l'Ecluse, Keeper of the Botanical Garden at Vienna. It was cultivated as a field crop in Ireland before **1663**. It did not reach the United States until **1719** when it was brought from Ireland by immigrants who settled at Londonderry, New Hampshire. The Irish potato reached the West Indies after 1700, and was first propagated from seed brought from the British Isles.

V. Dried specimens and representations of potatoes in terra cotta found in pre-historic tombs show that excellent varieties had been developed before the discovery of America.

VI. Numerous species of tuber-bearing Solanums have been collected in various parts of America both north and south of the equator, but *Solanum tuberosum* itself has never been found

[11]SCHIMPER, A. F. W. Planzen-Geographie, 665 and 741, 742. 1898.

in its wild state. Evidence as to the place of its origin points to the central Andean region where conditions of soil and climate are such that a number of plants of other families have developed tubers of a similar nature.

Gifted Children

GENETIC STUDIES OF CHILDREN, Vol. I. By LEWIS M. TERMAN, ET AL. Pp. 648, price $5.00. Stanford University Press, 1925.

This is a study, by Dr. Terman and thirteen collaborators, of the mental and physical traits of 1,000 gifted children in the California schools. The subjects were picked out as falling well within the upper one per cent of the school children, in respect of intelligence, and they have been studied from almost every possible angle, the result being a wealth of detail which can not even be suggested in a brief review, but which makes the volume by far the most valuable contribution available to a most important subject.

The group contains a significant preponderance of boys, yet the most brilliant individual found was a girl. Jews appear twice as frequently as expected from their number in the general population; the Latin races much less frequently. The Scotch, German, and English stand high—in general, it may be said that the Nordic stock predominates, but so does it in the population as a whole. There is one Mexican and two mulattoes.

In physical quantities the group stands well above par, as it does also in social and moral traits. Family influence is marked, and Dr. Terman concludes that the superiority of these children can be explained better as due to superior inborn endowment, than by any other hypothesis.

P. P.

A New Publication

ARBEITEN AUS DEM SEXUALPSYCHOLOGISCHEN SEMINAR von PROF. W. LIEPMANN, Berlin. Band I, Heft I, Sexualpsychologisches im Alten Testament, von Walter von Hauff, pp. 60, price 60c; Band I, Heft 2, Sexualpsychologische Studie zur Homosexualitaet, von Werner Hartoch; Das Weib in Weininger's Geschlechtscharkteriologie, von H. W. Brann, pp. 39, price 40c. A. Marcus & E. Weber's Verlag, Bonn am Rhein, 1924.

This new series, issues of which will appear at irregular intervals, appears to be on a higher level, scientifically, than is much of the German literature dealing with sex. The first booklet, by Professor von Hauff, covers more ground than its title might suggest, dealing with the ideas and practices of the Hebrews on marriage and parenthood, and bringing the study down to the development of Christianity.

P. P.